TROPICAL HYGIENE AND SANITATION

BAILLIERE'S ELEMENTARY TROPICAL HANDBOOKS

A Series of Handbooks providing a simplified though comprehensive approach to the fuller studies of students in training as Health Inspectors, Nurses and Medical Aids, Forest Rangers, etc, in tropical countries

Vol I ANATOMY AND PHYSIOLOGY, AND THE CAUSES OF DISEASE

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BAILLIÈRE'S
ELEMENTARY TROPICAL HANDBOOKS

TROPICAL HYGIENE AND SANITATION

A Course of Study and a Reference Book for Sanitary Inspectors in the Tropics

by

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WITH NOTES ON COMMUNICABLE DISEASES AND THEIR PREVENTION

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AND ON MEDICAL ENTOMOLOGY

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FOREWORD
TO BAILLIÈRE'S ELEMENTARY TROPICAL HANDBOOK SERIES

Baillière's Elementary Tropical Handbooks are designed for the use of students in tropical and subtropical countries They are simply written so that they can be used by those whose knowledge of English is too limited to enable them to use standard English textbooks Idiomatic expressions have, therefore, been avoided, but technical terms have not been excluded These are defined and explained, as it must be regarded as part of the student's education to master the commonly used technical expressions

Again, English textbooks are frequently too full for the tropical student, since they have been written to the syllabuses of State examinations Where, therefore, the detail was excessive or thought to be beyond the reach of the student in tropical countries it has been omitted, with the intention of keeping the book well within the student's grasp and yet making it sufficiently full to enable him to follow his profession with interest and intelligence

It must be understood that these books are intended to be accompanied by tuition Those who have had experience of teaching in the Tropics will appreciate the necessity for the most careful and

painstaking instruction and for that reason demonstrations and illustrations of a simple nature are also essential and details of these are appended to each chapter

It is a cause for much satisfaction that these small tropical handbooks have fulfilled their purpose, and we trust that they will grow in usefulness as the years go by.

JOHN P MITCHELL

PREFACE TO SECOND EDITION

The first edition of this Manual was intended primarily for Africans in training for the Sanitary Inspectors' Certificate of the Royal Sanitary Institute In this second edition additional material has been included in the hope that the book may be of equal service to students in any tropical or sub-tropical country A number of the drawings has been adapted and re drawn from type drawings issued by the Kenya and Uganda Medical Departments These are Figs 20, 48, 49, 56 and 64 from the Kenya Medical Department and Figs 12, 19, 52 and 55 from the Uganda Medical Department, which are acknowledged with thanks

Valuable help has been received from Dr J P Mitchell, C B E, who has revised completely his section on Communicable Diseases and has added information on diseases not mentioned in the first edition, from Mr G H E Hopkins O B E, who wrote the section on Medical Entomology and also from Dr Garnham who has revised this section and has supplied much additional matter especially about the newer insecticides and methods of using them

In conclusion I should like to record a special debt of gratitude to Dr H S de Boer, C M G, M C, who was responsible for the institution of the course of training for African Health Inspectors in

Uganda, for which this manual was first compiled and which owed so much to his continuous help and inspiration

H J

Sedgley,
January, 1950

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If we take gas from a large vessel and put it into a smaller one, we say that the gas has been compressed into the smaller space If we take gas from a small vessel and put it into a larger one, we say that the gas has expanded into the larger space

As gases are compressed they weigh more, and as they expand they weigh less, volume for volume

COMPOSITION AND PROPERTIES OF AIR

Air is a mixture of gases.

Air is composed of several gases, which are well mixed together, but which do not combine to form a new kind of gas It is invisible, but its presence is made evident to us in other ways We are conscious of inhaling it when we breathe, we can feel it blowing against us when it is in motion, either as wind or as a draught, we can see the movement of grass and trees and of ripples on water caused by it

Air takes up space.

To prove this, take an "empty" jar—i e, a jar filled with air, turn it upside down and press it under the surface of a bowl of water You will find that the water in the bowl does not rise and fill the jar The air in the jar prevents it from doing so Try the same experiment with a jar which has a hole in the top You will find that the water rises quickly and fills the jar, driving out the air through the hole in the top

Air has weight, can expand and is compressible.

Take a large bottle fitted with an airtight cork, and weigh it carefully Remove the cork and heat the bottle Now replace the cork quickly and reweigh the bottle, it will be found to be lighter than it was As the weight of the bottle is constant, the difference must be due to the change in the air in it What has happened is that the air in the bottle expanded when heated, and therefore required more space, some of it escaped into the surrounding air When the bottle was weighed the second

time there was less air in it than when weighed the first time Therefore the reduction of weight was due to a reduction in the weight of the air in the bottle and this experiment demonstrates two things

(a) That air expands when heated.
(b) That air has weight.

If the cork of the bottle is fitted with a valve of the type found on bicycle tubes another experiment may be tried

Allow the bottle to fill with air Put in the cork and weigh the bottle Now pump in more air with a bicycle pump Weigh the bottle again it will be found to be heavier than it was before the extra air was forcibly pumped in The air which was originally in the bottle has become more tightly packed or **compressed** to allow for the entry of more air This experiment demonstrates two things

(a) That air has weight.
(b) That air is compressible

Air varies in weight according to (a) its temperature and (b) its pressure

(a) According to its Temperature—In the above experiment it has been shown that air expands when heated and that a given volume of heated air weighs less than the same volume of cold air This is what we mean when we say that hot air weighs less than cold air It follows that in calculating the weight of a given volume of air we must know its temperature

(b) According to its Pressure—By pressure we mean the force of the weight of one body acting against another bo[illegible]

strength of your arm to do so in other words you must use upward pressure to counteract the downward pressure of the weight of the stone

Take a pair of scales and put a 10-pound weight on each side The scale will be exactly balanced because there is a pressure of 10 pounds on each side If you remove one of the weights, the scale on that side will go up and the other containing the remaining weight will go down Now put your hand into the empty scale and press When you are exerting a pressure of 10 pounds the scales will stand even If you use more pressure, you will weigh down your side of the scale, if you use less your scale will be higher than that containing the weight.

In the case of the second experiment with the bottle of air, where extra air was forced into the bottle with a pump, we found that there was an extra weight of air in the bottle, although the volume remained the same We now know that extra weight means greater pressure, and that to calculate the weight of a given volume of air we must know, not only its temperature, but also its pressure

ATMOSPHERIC PRESSURE

We call the air in which we live the **atmosphere** The atmosphere extends to a height of from 40 to 50 miles above the surface of the earth, and, as it has weight, it exerts pressure on that surface At sea level **atmospheric pressure** is at its greatest, and it becomes less as the ground rises above this level If we climb a mountain or go up in an aeroplane the atmospheric pressure becomes reduced as we rise, because there is less air above us

Atmospheric pressure is about 14 7 pounds per square inch at sea-level, and at a height of 2,640 feet (half a mile) it is nearly one tenth less

There is an instrument which is used for measuring air weight or atmospheric pressure This is called the **barometer.**

You can make a simple barometer for yourself Take a tube closed at one end and fill it with mercury Close the tube completely by placing your finger tightly over the open end Now invert the tube into a small basin of mercury and take away your finger You will find that, although some of the mercury has run out a

column of it remains in the tube. What is keeping it there? It is the pressure of the atmosphere on the surface of the mercury in the basin in which the tube is standing.

Repeat this experiment with another tube, and you will find that the second column of mercury is of the same length as in the first tube. This means that you have a measure of the atmospheric pressure.

A column of mercury such as this with lines marked on the tube to indicate the rise or fall of the mercury is a barometer and can be used to measure heights. Suppose that the mercury in a barometer stands at 30 inches at sea level; if the barometer is taken up to a height of 5,000 feet the mercury will be found to have fallen to 25 inches. The explanation is that there is less atmospheric pressure on the surface of the mercury in the bowl, and the column of mercury which is pushed up by the weight of the air is correspondingly shorter.

To calculate the Weight of Air.—For general purposes we may say that the weight of 13 cubic feet of air is 1 pound. We know, however, that the weight of air depends on its temperature and pressure.

For purposes of calculation we take the atmospheric pressure at sea level—i.e., 14.7 pounds per square inch—as a standard. The weight of any quantity of air at this pressure and at any given temperature may be ascertained by using a formula.

The formula for calculating the weight of a cubic foot of air at ordinary atmospheric pressure and at any given temperature (degrees Fahrenheit) is:

$$W = \frac{14.7}{0.37\,(T + 460)}$$

where W = weight of 1 cubic foot of air in pounds,
T = temperature (degrees Fahrenheit).

Example.—What is the weight of 1 cubic foot of air at a temperature of 70° Fahrenheit?

$$\text{Weight} = \frac{14.7}{0.37\,(70 + 460)} = 0.07496 \text{ pound}$$

THE COMPOSITION OF AIR.

Air consists of a number of gases, well mixed together but not chemically combined By this we mean that the various gases have not joined together to form a new gas but remain in their original form and retain their own properties

The most important of these gases are **oxygen, nitrogen, carbon dioxide and water vapour** The proportions vary a little but pure air may be said to be composed by volume as follows

Oxygen	20 96	per cent
Nitrogen	79 00	" "
Carbon dioxide	0 04	" "
Total	100 00	" "

Water vapour varies considerably in amount according to conditions which will be explained later

The Gases of the Air

Oxygen—Oxygen is an element—that is a simple substance which cannot be split up into other substances It has no colour, no taste and no smell **It supports combustion**—*i e*, it is necessary for the production of flame or heat It is required by animals and plants to sustain life which is dependent on the process of combustion It readily combines with many other substances heat and light being given out when the combination takes place Heat only is produced if the combustion is slow The compounds which result from the combination of oxygen and other substances are called **oxides**

For example if any substance containing carbon is burnt the carbon in it is released and combines with the oxygen in the air to form carbon dioxide During the process of burning which is also called combustion heat and light are given off but heat only if the process is very slow

Oxygen is necessary for Combustion—To show this burn a candle in an enclosed space As soon as the oxygen in the air in the enclosed space is exhausted

combustion stops and the candle ceases to burn. If the candle be lighted in the open it will continue to burn to the end, as it receives continuous supplies of oxygen from the air around it. We can put out any fire by excluding air, because by cutting off the supply of oxygen the process of combustion cannot continue.

Nitrogen.—Nitrogen is also an element; it is also colourless, tasteless and odourless. In other respects it is quite unlike oxygen. It does not support combustion. It is sometimes called the inactive part of the air because, in this form it is not used by animals or plants nor does it combine directly with the other elements.

It has a very important use however: it dilutes the oxygen in the air. Any substance which will burn in air burns more brightly in pure oxygen because the process of combustion is more rapid. Thus if the air were composed of pure oxygen, combustion would proceed at a much greater speed and life as we know it would be impossible. As it is, about four fifths of the volume of air is nitrogen, and plants and animals thus get the right amount of oxygen necessary to sustain life. Nitrogen exists in all living matter, but it is in the form of compounds of nitrogen only.

Carbon Dioxide.—Carbon dioxide is a chemical compound. It is made up of two elements, oxygen and carbon, which combine together to form a new substance. This substance has properties differing entirely from those of the two elements of which it is composed.

It is important to realise the difference between a simple mixture and a chemical compound. As we have seen, air is a simple mixture of gases.

In a chemical compound the proportions never vary. Carbon dioxide is always composed of 1 part of carbon and 2 parts of oxygen, and in no other proportion is it possible for this gas to be formed. Thus its chemical formula is written as CO —carbon 1 part, oxygen 2 parts.

The oxygen which forms part of carbon dioxide loses its individual properties when thus combined chemically, and it cannot now be used as is the oxygen in the air to support life or combustion.

Carbon dioxide will not burn; it will not support life or combustion.

Carbon dioxide is formed when the carbon in any substance is combined with oxygen as in the process of burning It is given off in the breath as a waste product of the burning processes in the body Plants give off carbon dioxide also when they breathe

Water Vapour.—If we pour water into a dish and leave it exposed to the air, the water will, in time, disappear If we hang wet clothing up in the air the water in the clothing will disappear What has become of the water in both these cases? It has been taken by the surrounding air in the form of water vapour We say the water has **evaporated**, meaning that it has turned into a gas and mingled with the air around it A certain amount of heat is necessary to make the process of evaporation possible, and, as a rule, the greater the heat, the quicker the process

You can test this by heating the water in your dish, it will disappear much more quickly than it would if left unheated If evaporation is taking place very rapidly, clouds of steam arise and then disperse into the atmosphere

and fall as rain

Think of the great surfaces of water—lakes, rivers, and seas—which are continuously exposed to the air and to the warmth of the sun, then you will understand why there must always be water vapour in the air Its function is very important Without it everything would be dried up

The quantity of water vapour in the air is not constant but varies with the temperature of the air and the local conditions for example, the higher the temperature, the more water vapour the atmosphere can hold.

If the air contains the maximum amount of water that it can hold at any given temperature it is said to be saturated with moisture Air which is so saturated cannot take up any more water vapour and the process of evaporation ceases Thus wet clothing remains wet, and water in open dishes and pools remains there The air is however very seldom completely saturated

The ratio between the actual amount of water vapour present in the air and the maximum amount that the air can hold at a given temperature is called the relative humidity of the air Thus if the maximum amount is taken as 100 and the atmosphere contains only half that amount we say that the relative humidity of the air is 50 per cent

Summary

(a) A gas has no definite shape or volume It expands indefinitely if not confined and may easily be compressed into a smaller volume
(b) Gases have weight and exert pressure The weight varies with the temperature
(c) The gases of the air form a simple mixture not a chemical compound
(d) Air consists mainly of oxygen and nitrogen with smaller quantities of water vapour and carbon dioxide
(e) Oxygen is the active part of the air
(f) Nitrogen is inactive, it serves to dilute the oxygen and it cannot support life or combustion
(g) Carbon dioxide is necessary to plant life

Exercises

1 What is the composition of ordinary atmospheric air?
2 What are the properties common to all gases?
3 Why do we say that air is a mixture of gases and not a chemical compound?
4 What is meant by "atmospheric pressure"?
5 Why is the pressure of the atmosphere less at the top of a mountain than at sea level?

What is the effect of heat on a gas?

(*d*) **Manufacturing Processes.**—Where machinery is used the air may be vitiated by smoke or by exhaust gases, or both

The exhaust or waste gases from motor-car engines and others of the same type (internal combustion) contain the poisonous gas carbon monoxide (CO)

Offensive trades, such as blood boiling, soap-making, bone boiling hide drying, gut scraping and so on, vitiate the air by foul smells and organic matters

How Polluted Air is Purified.

Impure air is purified in two ways

(*a*) By diffusion
(*b*) By movements in the air, or currents brought about by varying temperatures

(*a*) **Diffusion.**—Diffusion is the property which gases have of expanding indefinitely and of mingling with other gases They do this in spite of differences in their weight, or as the weight of gases is technically called, their density The gases of the air vary in weight or density Nitrogen is lighter than oxygen, and carbon dioxide is heavier, but we do not find these gases in layers in the atmosphere They have mixed or diffused into the mixture which we know as air, and their proportions to each other are practically constant—that is they vary very little even under varying circumstances

This diffusion of gases does not take place immediately two gases of varying densities come into contact with each other, at first there is a tendency for the heavier gas to remain under the lighter one, but after a time diffusion is complete, and the two gases have formed a perfect mixture

Air, which is a mixture of gases, retains this property of diffusion, and, if confined in a vessel of porous material such as unglazed earthenware, will gradually mix with the outside air, the process of diffusion taking place through the sides of the vessel

It follows from this that even if a room is unventilated there will always be a certain amount of change of atmosphere in it by diffusion through the walls This

process is however much too slow for practical purposes and moreover the better the materials of which the house is built the slower the process will be Diffusion therefore cannot be relied upon as the sole means of ventilation

(b) Purification by movements caused by varying temperatures is the chief natural means of ventilating rooms The quickest but not always the best way to change the air of a room is to open the doors and windows and to let the wind blow through Wind is simply air in motion Hot air is lighter than cold air cold air being heavier exerts more pressure falls and pushes the hot, light air out of its way Thus we get moving air which on a large scale we call wind or on a smaller scale draught

Convection Currents —Convection currents are caused

into contact with the hot parts they absorb some of their heat and themselves become warmer Similarly the heated air giving out some of its heat becomes cooler This movement of parts of the air and the interchange of heat continues until the whole mass of the air in the room has reached the same temperature This process is called **convection**, and convection currents are the streams of air which are set in motion while the process is going on

The air of an occupied room is heated by the breath and by the body heat of the occupants also by fires or by lamps burning in the room The air becomes warmer than the air outside the room It becomes lighter and therefore its weight or pressure becomes less If cold fresh air is allowed to enter from the outside it pushes the warmer lighter and impure air upwards So we take advantage of this knowledge when providing means of ventilation by making **outlets** for hot vitiated air near the top of the room and **inlets** for fresh air in the walls lower down

would mean a complete change of air once an hour as the rooms of such a dwelling would have to be very large and would therefore be very costly to build In practice a smaller air space is provided and the air is changed more frequently—*e g*, if 500 cubic feet of air space is provided the air would need to be changed

$\frac{3000}{500}=6$ times per hour

By changing the air six times per hour we do not mean that the air is allowed to remain stagnant for one sixth of an hour and is then suddenly removed and replaced by fresh air The change must go on gradually and constantly at such a rate that at the end of an hour the air has been completely changed the required number of times

Calculations Necessary

In order to estimate the amount of air admitted or delivered to a room in an hour it is necessary to know the sectional area of the inlets and outlets and the rate or velocity at which the air is flowing in and out of the room The formula is

Quantity of air delivered per hour$=A\times V\times 60$

where A=total area of inlets or outlets

V=velocity of air in feet per minute

60—number of minutes in one hour

Example 1—How many cubic feet of air per hour will be delivered to a room which has two inlets each 1 square foot in sectional area if the velocity of the incoming air is 60 feet per minute?

Solution—Quantity of air delivered per hour= $A\times V\times 60$

where A=total area of inlets

V=velocity of air in feet per minute

60—number of minutes in one hour

If Q=quantity of air delivered per hour

$Q=2\times 60\times 60=7200$ cubic feet.

Example 2—What will be the total sectional inlet area required to change completely six times per hour

the air of a room of 2 000 cubic feet capacity? The velocity of the incoming air is 60 feet per minute

Solution—Amount of air to be delivered per hour $= 2\,000 \times 6 = 12\,000$ cubic feet

$12\,000 = A \times V \times 60$

$$\therefore A = \frac{12000}{60 \times 60} = 3\tfrac{1}{3} \text{ square feet.}$$

The velocity of air in feet per minute can be measured with the aid of an instrument called the kata thermometer This instrument is also known as a "comfort meter It consists of a glass bulb and a stem The bu b is filled with spirit and on the stem are two marks The higher mark indicates the level to which the spirit rises in the tube when at a temperature of 100° F, the lower mark indicates the level reached by the spirit when at a temperature of 95° F The word "kata" is a Greek word meaning down and in using the kata thermometer a record is made of the time taken by the spirit in the tube to fall from the level of 100° F to that of 95° F The length of time taken will depend on the cooling power of the air and is therefore an ind cation of that power The greater the cooling power of the air the shorter will be the length of time taken by the spirit in the tube to fall 5° in temperature

above
s level
noted
s bulb

into a flask containing hot water)

This estimating the cooling power of the air in rooms is the most important use of the kata thermometer as the comfort of the occupants depends to a large extent upon this cooling power Full instructions for its use for this purpose are provided with each instrument the management of which is best learned by actual practice It should be noted that if recordings are to be of practical value observations should be taken at the same time and on the same day both inside and outside the building which is being tested

It is because the cooling power of the air depends partly upon its velocity that the velocity of the air can be calculated by means of the kata thermometer, together with the chart which is provided with the instrument for this purpose

Rate at which Air may be Delivered.

If the velocity of the air is too great, draughts are produced

A draught is a stream of air at a lower temperature than that of the room, which when directed upon the body or part of the body, produces a feeling of chill and discomfort

The velocity at which air should be delivered therefore, depends upon its temperature At 75° F a comfortable velocity would be about 100 to 200 feet per minute for a room, such as an office or classroom in which sedentary work is carried on If the temperature is higher, the velocity may be increased without causing draughts, if it is lower the velocity should be decreased

Quantity of Air Space.

The minimum amount of cubic space which should be provided for each occupant of a room varies with different types of buildings and with the uses to which they are put

The following amounts may be taken as a general guide

Type of Building	*Number of Cubic Feet per Person*
General hospital	1,200
Infectious diseases hospital	1,872 (2,000 for small-pox hospitals)
Sleeping rooms	500 (minimum height 10 feet, minimum floor space 50 square feet)
School classrooms	125 for each pupil and 500 for teacher
Dormitories (labour camps etc)	
Cowsheds	

Floor Space

In considering cubic space in connection with ventilation the question of floor space must be taken into consideration The cubic capacity of a room might be adequate for the number of people who are to occupy it and yet its shape might make it quite unsuitable for human habitation

For example a room of the capacity of 2 000 cubic feet would accommodate four people provided the dimensions are suitable

Suitable dimensions would be $15 \times 13\frac{1}{3}$ feet (floor space) $\times 10$ feet (height) $= 2\,000$ cubic feet

But if we heightened the room to 20 feet the floor space would be reduced accordingly as follow 10×10 feet (floor space) $\times 20$ feet (height) $= 2\,000$ cubic feet.

With this height of room ventilation would be bad and the floor space would crowd the occupants and increase the risk of droplet infection

Again if we increased the floor space unduly the height of the room would be reduced below the accepted minimum of 10 feet

PRACTICAL METHODS OF VENTILATION

Definitions.

Methods of ventilation are grouped under two headings (1) Natural Ventilation (2) Artificial Ventilation

(1) **Natural Ventilation**—The methods which come under this heading make use of the natural forces of diffusion and the movements due to varying temperatures of the atmosphere They are usually employed in dwellings and in such buildings as schools and hospitals

(2) **Artificial Ventilation**—The methods which come under this heading require the use of some mechanical apparatus such as fans either to force in fresh air or to extract foul air They are usually employed in very large buildings such as blocks of offices public halls theatres and so on

Natural Ventilation of Buildings.—In occupied rooms the air becomes heated by the heat of our bodies and

Fanlight—One of the best types of window is that which has a small part at the top made to open independently of the rest of the window This is called a fanlight It may remain open at night or in bad weather when the main part of the window is closed

In order that they may remain open in bad weather fanlights are best arranged with hinges at the top or bottom or they may be pivoted at the centre

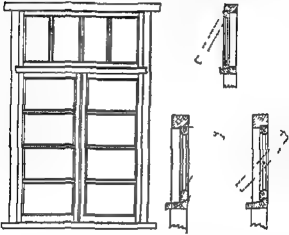

Fig 3 —Fanlights

Each of these three methods is shown in Fig 3 Note that when hung from the bottom the fanlight is made to open inwards

In hot countries and for a cheaper class of building the space usually occupied by the fanlight may be left empty and covered with wire gauze as a protection against mosquitoes and other insects

Hopper Windows are very suitable for schools hospitals and similar buildings They are windows which are hung at the bottom wings being provided to close

the sides Incoming air is directed upwards and is not felt as a draught, these windows may be allowed to remain open even during heavy rain (see Fig 4)

Sliding Sashes.—A window made with sliding sashes is a very good type for ventilating purposes, but one which is rarely found in modern buildings and is never met with in the tropics (see Fig 5)

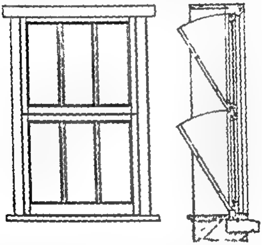

Fig 4—A Hopper Window

Casement windows (see Fig 6) arranged on at least two sides of a room are very satisfactory When it is raining or when strong winds are blowing from any direction, the windows on the windward side may be closed and the others left open

Protection of Windows.—In malarious districts all windows must be protected by wire gauze against the ingress of mosquitoes These wire guards, if made to open, should always be closed from sundown to sun rise

When a fire is burning this action is very much increased The air in the flue is heated becomes lighter rises and is replaced by the cooler air behind it. The heated air travels up the flue at a rate of from 3 to 6 feet per second and fresh air comes in through the inlets of the room at the same rate to take its place

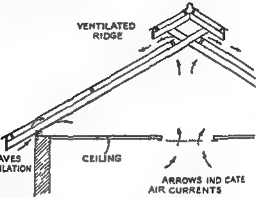

FIG 8 —VENTILATED RIDGE ETC

In this way with an ordinary flue 9 by ▮ *inches* from 6 000 to 12 000 cubic feet of air per hour will be pushed out of the room and will be replaced by cool fresh air

Rule —Discharge of hot air in cubic feet = velocity of air in feet × area of flue in square feet

Example —The sectional area of a flue is 12 by 12 inches

The velocity at which the air is moving in a flue 5 feet per second

How much air will be removed from the room in one hour?

Solution —Discharge of air in cubic feet per hour $=5 \times 3\,600 \times 1$

18 000 cubic feet per hour

velocity in which the air is moving in a flue ascertained by using an air meter The following however gives a method of estimating approxi velocity

$$\text{Approximate velocity} = 6\sqrt{\frac{(T-t)\times H}{491}}$$

ich T = temperature degrees F inside the flue
t = temperature degrees F of room
H = vertical height of chimney

amples.—A flue is in by 12 inches inside measure Its height is 12 feet. The temperature of the air e the flue is 100° F and that of the air of the room 5° F What will be the approximate discharge in c feet per hour of air from the flue?

olution.—Velocity of air in feet per second

$$= 6\sqrt{\frac{(T-t)\times H}{491}}$$

$$= 6\sqrt{\frac{(100-75)\times 12}{491}}$$

$$= 6\sqrt{\frac{300}{491}}$$

∴ Velocity of air in feet per hour

$$= 3\,600 \times 6\sqrt{\frac{300}{491}}$$

By Formula I discharge of air in cubic feet per hour = velocity of air in feet per hour × area of flue in square feet

$$= 3\,600 \times 6\sqrt{\frac{300}{491}} \times 1\cdot5$$

$$= 3{,}600 \times 9 \times 0\cdot781$$

$$= 25{,}304\cdot4 \text{ cubic feet per hour}$$

Artificial Ventilation.

Under this heading come all methods of ventilation which rely upon mechanical devices to set air currents in motion Of these there are two systems in general use

1 **The Extraction Method** —By this method the vitiated air is extracted from the room by revolving fans usually driven by electricity and fresh air comes in from outside to take its place This method is especially suitable for factories in which dusty or otherwise dangerous trades are carried on

Care must be taken to place the inlets in such a position that the incoming air will be drawn only from the outside and not from corridors closets or other undesirable places

2 **The Propulsion Method, or Plenum System** —By this method the air is driven into the room by fans and the vitiated air is allowed to escape by special outlets While this system is in operation doors and windows must be kept closed It is a suitable method of ventilation for large public buildings such as theatres which are temporarily occupied by large numbers of people

HOW TO INSPECT VENTILATION

Practical Details

Time of Inspection —It is important to make the inspection while the room is being used for its normal purpose and if possible towards the end of the period of occupation

Methods to be Adopted

(*a*) Immediately you enter the room notice your sense impressions Does the atmosphere feel hot and stuffy? Is there an unpleasant smell or body odour?

(*b*) Are the windows open or closed?

(*c*) Are the ventilators open or are they stuffed up or covered in any way?

(*d*) Take wet and dry kata readings and the temperature of the room Take your note-book and enter the answers to the above questions and the kata readings

Next draw a rough plan and section of the room and then proceed to take the following particulars

(*a*) Number of occupants adults and children over ten years of age then children under ten years of age

(b) Length, breadth and height of the room
(c) The size—length, breadth and height—of any large obstruction, such as a large cupboard This will be worked out later and deducted from the cubic capacity of the room
(d) The kind of windows To what extent they are made to open, their number, situation and area Do they all open to the external air?
(e) Number and position of the doors and with what do they communicate—passages, rooms or external air?
(f) Number, size, kind and position of permanent ventilators Do these open directly to external air or to a verandah enclosed by wire gauze?
(g) Note any other matters affecting ventilation—e.g., fireplaces, with or without flues, lamps materials of which walls are constructed roofs, method and materials of construction whether or not a ceiling is provided.
(h) Calculate areas (floors, windows, etc) and cubic capacities (of room, obstructions, etc) ascertain if conditions are found to comply with legal requirements or the laws of hygiene

Return to your office and make a good sketch drawn to a suitable scale, of the premises inspected, and write a report setting down all your facts and calculations

Note.—When calculating cubic space for ventilating purposes, it is usual to neglect any height in excess of 12 feet.

Exercises.

1 What is meant by "cross-ventilation" and "through ventilation"? Distinguish between natural ventilation and artificial ventilation
2 Make a sketch to scale of a dormitory suitable for the accommodation of twelve adults Indicate number sizes and position of windows and ventilators Calculate the floor area and the total volume of the room
3 Give a list of offensive trades, and show in each how the surrounding air is vitiated by the

4 Describe the different types of window known ■ you, stating what you consider to be the advantages and disadvantages of each type Illustrate by sketches

5 How would you ventilate (a) a building constructed of mud and poles with thatched roof, (b) a sleeping room constructed of brickwork with corrugated iron roof? Illustrate by sketches

6 What are convection currents? How are they set in motion? What practical use can be made of a knowledge of these currents in planning the ventilation of a building?

7 What is meant by the 'allowable respiratory impurity' of air? Does an excess of carbon dioxide always denote respiratory impurities in the air of a room?

8 Four people occupy a room the cubic capacity of which is 2 000 cubic feet. If the velocity of the incoming air is 60 feet per minute, what will be the total sectional inlet area required to change the air of the room completely six times per hour?

9 What do you understand by 'overcrowding" in a sleeping room? What diseases are likely to be spread by such a condition?

10 What is a 'back to back' room? State for what purposes you consider such a room to be undesirable, giving reasons in each case

CHAPTER II

WATER

Water ■ not only essential to life, but a plentiful supply of clean water is necessary for the well being of any community large or small, for without an ample water supply houses, clothing and persons cannot be kept clean In selecting a site for a house or village therefore the first consideration should be the presence, within a reasonable distance, of a good supply of usable water

A plentiful supply having been secured it is necessary that the people who are to use it should be shown how to protect it, so that it may be kept clean and may not become a source of danger, they should also be taught how to deal with water which is to be used for drinking or in the preparation of food. This is necessary because water is a medium for the transmission of many diseases including

1 Those in which the infecting organisms are carried by water such as dysentery diarrhœa the enteric fevers and cholera
2 Those which are caused by parasitic worms such as ankylostomiasis or hookworm disease bilharzia or schistosomiasis guinea worm ascariasis and flukes.
3 Those in which the infection is carried by insects which breed in water such as malaria yellow fever and filarial diseases

CHEMISTRY AND PHYSICS AS APPLIED TO WATER

What is Water?

Pure water consists of a **chemical combination** of the two gases oxygen and hydrogen in the proportion of 2 volumes of hydrogen to 1 of oxygen. Its chemical formula is H_2O

Hydrogen is an element. It is a colourless gas which cannot support combustion, but which is itself very inflammable It is about fourteen times lighter than air and for this reason was used to fill balloons of the old type and also some types of modern airships

Oxygen is described in Chapter I pp 6-7

Water is a very good example of a chemical compound The two elements oxygen and hydrogen the properties of each of which are very different from those of the other, combine to form an entirely new substance having no property in common with either of them. Pure water will not support combustion It is not inflammable It will not support life for fishes and other

is again put under pressure by the pump until it becomes liquid The process continues, the compressed liquid being released within the expansion pipe, where it becomes gaseous again, and so the ammonia circulates and extracts heat from the brine until at last the temperature of the brine is lower than the freezing point of water—that is, it is lower than 0° C.

The cold brine is made to circulate in pipes through a chamber in which trays of water have been placed, taking heat from the water and from the air of the chamber as it goes The temperature of the chamber is thus lowered until it reaches freezing point and the water turns into ice

Such a chamber may be used for the preservation of food by cold storage as well as for the manufacture of ice

WATER AS A GAS

When water is boiled it is converted into about 1,700 times its own volume of steam Thus if a pint of water is converted into steam, 1,700 pints of steam are formed This steam is almost entirely free from any impurities which may have been present in the water, the impurities remain in the vessel This fact is made use of when pure water is needed for chemical and other purposes The steam from boiling water is cooled by passing it through a coil of pipes round which cold water circulates until it becomes liquid The water which flows from the coil is called distilled water

How Water Boils in an Open Vessel.—Water has the power of dissolving many gases and in all water there is a certain amount of dissolved air When water is heated, the first thing that happens is that this dissolved air is driven off and escapes from the surface of the water Then the molecules of the water nearest to the source of heat expand and rise, the cooler ones from the top sinking to take their place This process of circulation continues becoming more and more rapid until all the water has been raised to boiling point. When the water is boiling the molecules are moving so rapidly that they overcome the pressure of the atmosphere on the

surface of the water and escape in the form of a gas or steam

At sea level the atmospheric pressure is 14.7 pounds per square inch and water boils at a temperature of 212° F This then is taken as the **standard boiling point of water** We have learnt that as we ascend from sea level the atmospheric pressure becomes less there fore on heating water at a high altitude boiling occurs at a lower temperature it being easier for the water molecules to overcome the air pressure At the height of half a mile for example the air pressure is about 13.23 pounds and water boils at 206° F

Latent Heat of Steam—When water reaches boiling point the continued application of heat to it does not raise its temperature Why is this so? It is because the extra heat is used up in converting the liquid water into water gas or steam Steam therefore is actually water raised to boiling point plus the heat expanded in con verting it into water vapour or steam But if you take the temperature of steam you will find that it is the same as that of the boiling water Where then is the extra heat which has been applied? It is not wasted—it is in the steam but curiously enough it is not registered on the thermometer That is why it is spoken of as **latent heat**, which means that it is concealed or hidden in the steam itself

Condensation of Steam—The moment the latent heat of steam is withdrawn from it the steam condenses again It becomes water Such steam is spoken of as **saturated steam.** It has the same temperature as the water from which it is produced and condenses to water immediately on losing its latent heat.

Superheated Steam—Superheated steam is not ordin ary steam It is steam which has been made hotter by artificial means It is steam which has had more heat forced into it by passing it through a chamber which has a higher temperature than bo ling water In th s process the steam absorbs heat in excess of its latent heat There fore before it can be condensed into water again it must first give up the added heat and thereaft r its latent heat Thus it takes longer than ordinary steam to

necessary to fish life and *further it helps* to purify polluted water by oxidising organic impurities Ammonia if present in any quantity is an indication of recent pollution by urine

water used for drinking and for domestic purposes Lead is very poisonous and is usually found only in very soft water which has been in contact with lead pipes *lead lined tanks etc*

Hard and Soft Water

Hardness is estimated according to the number of grains of the hardening substance contained in 1 gallon of the water One grain per gallon gives 1 degree of hardness 2 grains gives 2 degrees and so on Water containing more than 10 grains of hardening substance to the gallon—i e water of more than 10 degrees of hardness—is called hard below 10 degrees it is called soft Very hard water has disadvantages which are as follows

(a) Hard water wastes soap and is unsuitable for laundry work
(b) Vegetables and other foods are not so digestible when cooked in it.
(c) When used in the boilers of for example steam engines a deposit is formed on the inside of boilers and pipes This causes waste of fuel as much more heat is needed to raise steam The deposit also tends to block the pipes *Such deposits can be seen inside kettles* in which hard water is boiled

Softening of Water—Water which is too hard may have the hardness removed or reduced by taking away all or some of the substances which cause the hardness

The methods employed to do this depend on the nature of the hardness of which there are two kinds—temporary hardness and permanent hardness.

Temporary hardness is usually due to the presence of calcium carbonate or magnesium carbonate These are substances which can be dissolved only in water which contains carbon dioxide if we remove the CO_2 from the water they will be precipitated—i e they will cease to be dissolved they will become solid and fall in the form of a powder to the bottom of the water the water having lost its CO_2 is no longer able to hold them in solution

CO_2 may be removed from water by boiling a proce s which drives off the gases It may also be removed by adding lime The lime unites with the CO_2 in the water and forms calcium carbonate which is insoluble and falls to the bottom as a precipitate

For large supplies of water 1 ounce of quicklime is added to every 1 000 gallons for each degree of hardness [illegible]

Hardness which can be removed either by boiling or by the addition of lime is called temporary hardness.

Permanent hardness is due to the presence of substances which are soluble in water even when it does not contain CO_2, and which cannot, therefore be removed either by boiling or by adding lime these substances are usually calcium sulphate or magnesium sulphate and it is difficult to remove them and at the same time leave the water fit for drinking purposes This may be done by passing the water through a substance known as permutit, which possesses the power of absorbing lime and magnesium salts.

If the water is required only for laundry purposes it may be softened by the addition of sodium carbonate (washing soda) This results in the formation of sodium sulphate and calcium or magnesium carbonate the latter is precipitated and the former remains in the water but does not cause hardness

surface of the candle After a time the candle becomes coated with such matter and requires to be cleaned. It should first be brushed to remove the deposit, and then be boiled to sterilize it (see Fig 9)

A filter such as the above is suitable for filtering drinking water for a small family only, because it works very slowly If larger supplies of filtered water are needed pressure filters fitted with more or larger candles are used. In pressure filters the candles are fitted into a closed metal cylinder, and a *pressure of about 35 pounds per square inch* is used to force the water through them quickly Such filters are used in large institutions, such as hospitals and mineral water factories

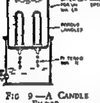

FIG 9—A CANDLE FILTER

Filtration of Large Supplies of Water—For filtering large supplies of water two forms of filter are used These are the slow sand filter and the mechanical sand filter

Slow Sand Filtration—This is the oldest and still one of the best methods of filtration on a large scale Its disadvantages are the large size of the filter required and the slow rate at which the water passes through, owing to the fact that no pressure is used

The slow sand filter consists of an open tank about 6 feet deep, with an arrangement of open jointed field pipes laid on the bottom, these pipes receive the filtered water and convey it from the filter Embedding the pipes is a layer of coarse gravel about 1½ feet deep, and above the gravel is a layer of sand 2½ to 3 feet deep The remaining portion of the tank contains the water to be filtered. The tank is fed from a pipe leading from the reservoir

As the water sinks through the filter organic matters, including various bacteria are strained out and are left on the surface of the sand After a few days' flow these organisms increase and form a thin **gelatinous layer** or film covering the entire surface of the sand This film is of the greatest value for it prevents the passage through

the filter of the smallest organisms, including disease germs Until this film has formed the filter does not function properly, so the water which has passed through before its formation is allowed to run to waste The time taken for the film to form and to become effective is about three days After this it gradually thickens until, after a period varying from three weeks to three months it becomes so thick that the water can pass through it only very slowly When this stage has been reached the [illegible]

use.

Slow sand filters can deal with an average of 50 gallons of water per day for each square foot of their surface area

Mechanical Sand Filter—The mechanical sand filter consists of a closed steel cylinder containing sand and gravel to a height of about 4 feet, through which the water is forced by pressure These filters also depend upon the formation of the gelatinous film for their efficiency The rate at which the film is formed and the length of time taken for it to become too thick depend upon the amount of water which passes through the filter in a given time

Mechanical sand filters are usually capable of dealing with about 2 500 gallons of water per day for every square foot of their surface area that is they work about fifty times as fast as does a slow sand filter The film forms and becomes thick much more quickly the average time taken for formation is from three to four hours, and after three or four days it becomes too thick for economical working

When the film is too thick it must be removed This is done first by forcing air through the filter from below upwards The air breaks up the film and loosens the sand Following the air a stream of filtered water is forced through in the same direction The water washes the sand and the gravel The dirt is washed slowly away from the bottom upwards and passes out through

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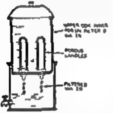

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Slow sand filters can deal with an average of 50 gallons of water per day for each square foot of their surface area.

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When the film is too thick it must be removed. This is done first by forcing air through the filter from below upwards. The air breaks up the film and loosens the sand. Following the air a stream of filtered water is forced through in the same direction. The water washes the sand and the gravel. The dirt is washed slowly away from the bottom upwards and passes out through

treat 2 000 gallons of moderately polluted water Or

(b) Make a stock solution and use it for treating small quantities of water when necessary The stock solution is prepared as follows Make a level *teaspoonful of chloride of lime* into a smooth paste with water; dilute this with 4 teacupfuls of water and keep in a tightly corked bottle One teaspoonful of this stock solution should be put into each 2 gallons of *water, which should then be allowed to stand* for fifteen minutes It should be safe to use the water for drinking after this period

Other Methods of Water Sterilization on a Small Scale—Permanganate of Potash—Sufficient should be *added to give a pink tint to the water If the colour* [illegible] safe, and more [illegible] tablet form [illegible] art of water [illegible] *one hour*

Distillation—This method is used by chemists when they need pure water The apparatus needed to carry out this process consists of a boiler from which a coil of pipe runs into a vessel through which passes a con *stant stream of cold water* The water in the boiler is heated to boiling point steam rises from the surface of the water and passes into the cold pipe where it con denses into water again

Distilled water contains no organic or inorganic impurities, but it is not palatable and the process is too expensive for ordinary use The water may be aerated after distillation if this is done it makes excellent drink ing water

Sources of Water Supply

Supplies of water for ordinary purposes may be obtained by the following methods

1 Collecting rainwater from a clean surface such as a corrugated iron or a tiled roof—i e **direct rainfall**

2 Constructing reservoirs in the high lands to collect water from the surface of clean unpolluted ground. This is known as **upland surface water**
3 Taking water from rivers streams or lakes this is also surface water
4 Collecting underground water as it issues from the ground in the form of **springs** or from wells dug or bored for the purpose

Direct Rainfall

If rainwater is collected from clean roofs and stored in clean tanks it is the purest of all natural waters

Rain is formed by the condensation of water vapour produced by evaporation from the water of the oceans lakes and rivers It therefore contains no solid impurities until it falls upon a dirty surface such as a roof fouled with dust, dead leaves and the excreta of birds

If rainwater is to be collected for use as drinking water the roof must be provided with proper eaves gutters and down pipes discharging into covered and protected storage tanks These tanks may be constructed of galvanized iron or better of concrete provision must be made for frequent cleaning and a tap must be provided for the withdrawal of the water

this automatically causes the first portion of each rainfall to run to waste thus ensuring that the roof is washed before any water is allowed to run into the storage tank

The disadvantages of direct rainfall as a water supply are the intermittent nature of the supply the liability to pollution from dirty roofs and storage tanks and the fact that *rainwater is tasteless and unpalatable owing to* the absence of aeration and of minerals

To estimate the Quantity of Rainwater Available.—The quantity of rainwater falling upon a surface may be estimated as follows

treat 2 000 gallons of moderately polluted water Or

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Sodium Sulphate—This is obtainable in tablet form *Two tablets should be dissolved in a quart of water* which should then be allowed to stand for one hour

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device called a **rainwater separator** is sometimes used this automatically causes the first portion of each rainfall to run to waste thus ensuring that the roof is washed before any water is allowed to run into the storage tank

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Reservoirs

Reservoirs are usually partly natural and partly artificial For example a valley may be converted into a reservoir by the erection of a concrete or earth dam across a narrow part The water is led from the reservoir to the filters and thence to the town by large steel or concrete pipes called **mains**

If possible the reservoir is constructed at such a height that the force of gravity alone is sufficient to raise the water in the mains to the highest part of the town. If this is impossible pumps have to be used and the expense of providing a water supply is greatly increased

Lakes and Rivers.

Lakes and rivers are common sources of water supply They are under the best conditions liable to be polluted in the manner described above and when their shores or banks are thickly populated they are more especially liable to pollution In manufacturing districts too *waste water and other refuse from factories is often* turned into a river So also is the effluent from sewers and drains

Even in a country where there are not many sewers rivers are polluted because of the insanitary habits of the people who live near to them If latrines are not used the ground becomes very foul and filth is washed into rivers and streams by the rain In many places cattle and goats are allowed to pollute the places from *which water is drawn*

If a village derives its water from a river this should be divided into sections each of which should be reserved for a particular purpose The upper reaches should be protected and used only for the drawing of drinking water An area on both banks should be fenced The banks themselves should be trimmed and where necessary stones should be laid down to form a hard surface so that mud shall not be formed by the traffic to and from the water Down river from this section other sections of the river should be reserved—one for bathing one for the washing of

clothing and, last of all, one as a drinking place for cattle should be made

All water drawn from a source like this should if drawn for drinking purposes, be stored, filtered and sterilized Under no circumstances should it be used unless it has at least been allowed to stand for a while to clear itself, and then it should be boiled These two processes can, and should, be carried out under the most primitive of conditions

When a river [redacted] used as a source of water supply on a large scale, the water needs to be carefully purified before delivery to the consumer Preliminary storage to allow of sedimentation is always necessary before filtration and sterilization can be undertaken

Sometimes [redacted] is possible to improve the quality of water derived from a river by sinking wells [redacted] some distance from its banks The water percolates through the soil between the river and the well and is thereby partially filtered Care must be taken to exclude surface water from such wells, but the subsoil water may be allowed to enter, unless there is reason to fear that it may be less pure than the river water

Another method sometimes adopted is to dig trenches parallel to the river bank and at some distance from it so that water may seep through the intervening ground from the river to the trench The digging of wells [redacted] the better method, as these are more easily protected than trenches

River and lake water [redacted] classified as surface water and is usually soft

Springs and Wells.

Water derived from either of these sources is classified [redacted] underground water and is usually harder than surface water, owing to the minerals dissolved in it during its passage through the soil

Origin [redacted] Ground Water.—The original source of all waters [redacted] the rainfall Some rainwater evaporates and returns to the air to fall again as rain, some runs off the surface of the ground to form streams rivers and

through the soil before finding an outlet, a great deal of natural filtration has taken place Contamination may, however, occur if the surface pollution is great and if, at the same time, the upper impervious stratum contains numerous cracks through which the water may trickle down without any natural filtration taking place

Owing to the minerals and gases which the water dissolves during its journey through the rocks, deep spring water is usually very hard and sparkling

Protection of Springs.—If a spring is used as a source of supply for drinking water, every effort must be made to prevent pollution during collection It is not sufficient to make a hole near the spring and to scoop up the water from this, some arrangement of pipes should be used so arranged that the water may enter the collecting vessel in as pure a condition as it was when issuing from the orifice, or eye, of the spring

Fig 12 shows a method of doing this recommended by the Medical Department of Uganda and used in that country with successful results

The wall or dam (*a*) should be watertight, and may be built of stone or brick in cement mortar, or it may be constructed of concrete It should be built a little in front of the eye of the spring The 2 inch galvanised iron pipe should be fixed near the bottom of the dam and it is recommended that the water should not be allowed to rise in the space behind it, as the pressure thus caused usually results in leakage round the sides of the dam It is for this reason that an overflow is provided 8 inches above the bottom of the pipe The overflow (*b*) should lead into a covered rubble or french drain It has been found in practice that people frequently plug the outlet pipe with the mistaken idea that this will conserve the water supply, in such cases the overflow prevents the accumulation of water behind the dam, with the consequent danger of leakage or even of bursting

The outlet pipe should be so arranged as to obtain a minimum height of 1 foot 3 inches between its discharge end and the place on which the buckets which

receive the water are to stand, this can be done on sloping ground by giving sufficient length of pipe and on level ground by siting the concrete stance at the proper distance below the pipe

The spring may be covered over with corrugated iron sheets, on the top of which is a layer of earth as

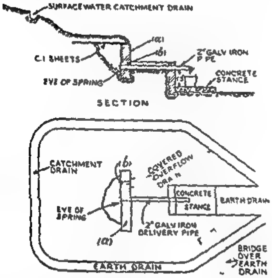

FIG 12—A PROTECTED SPRING

shown in the sketch or it may be covered with concrete or even with poles and earth. The latter is not recommended as the poles are very liable to be attacked by white ants

The waste water should be carried away by an earth drain and the whole collecting scheme should be pro-

(c) The top of the well should be covered with concrete and, in addition, should be provided with a concrete surround several feet wider than the outside circumference of the well The concrete surround should be raised above the ground level The water should [redacted] drawn by a pump, dipping with buckets or other vessels should not be permitted

Fig 14 illustrates the above points

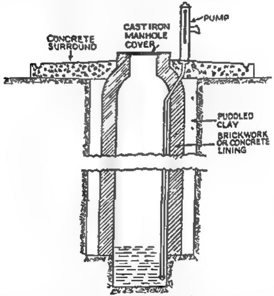

FIG 14 —THE PROTECTION OF A WELL

Deep Wells—These, as a rule, are dug out for the first 10 feet, and are then completed by borings of smaller diameter *The borings are lined with steel pipes*

The dug portion of the well should [redacted] protected in a manner similar to that described for *shallow wells*

QUANTITY OF WATER REQUIRED

When the question of the provision of water supply for a village or town is being considered it is necessary to know for what purposes the water will be required

Under any circumstances each individual in the community needs water for drinking bathing the washing of clothes and the cleansing of the house There may be animals to be provided for There may also be public Institutions, such as schools hospitals and hotels which have special needs In towns the amount of water required for water-closet and drain flushing for the washing of streets and for manufacturing purposes must also be taken into account

The minimum amount of water required for a village community is about 12 gallons per head per day this amount is made up as follows

Drinking water	0 3 gallon
Cooking water	0 7
Bath etc, water	5 0 gallons
Laundry water	3 0
House cleansing water	3 0
Total	12 0

Special Requirements

Hotels	30 gallons	per head	per day
Hospitals	40-50 ,,		
Schools	10	,,	,,
Horses	16	,,	,,
Cows	10	,,	,,

In large towns in Europe the allowance of water per head varies from 27 gallons to [illegible] gallons per day according to the needs of local industries and to the cleansing methods employed by the local authority

Taking an average of 35 gallons per head per day this allowance would be allocated as follows

If a sample is to be taken from a river or lake, the bottle, with stopper in place should be submerged to a depth of 1 foot below the surface The stopper should then be removed and the bottle allowed to fill The bottle is sunk in this way to avoid the collection of water near the surface which may be of better quality owing to its contact with the air

If a sample is to be taken from a tap or pump the water should be allowed to run to waste for a few minutes in order to clean the mouth of the outlet The water which has been standing in the pipe should be run off before the sample is taken

The sample must be taken without delay to a chemist, together with the following information

(*a*) The source from which the sample was taken

(*b*) The kind of apparatus used for drawing the water

(*c*) If from a well, full details of the well and its surroundings.

(*d*) If the sample is of surface or rainwater details of the kind of collecting surface and of means of storage

(*e*) The state of the weather—*e g* has there been a long dry spell or a period of excessive rain?

For Bacteriological Examination—The greatest care must be exercised in collecting samples for this purpose otherwise the results obtained will not be conclusive

Properly **sterilized glass bottles with glass stoppers** must be used if possible these should be obtained from the laboratory ready for use Any part of the bottle or stopper which comes into contact with the water to be examined must not be touched with the fingers or allowed to come into contact with anything excepting the water collected.

The filling of the bottle should be done in the same manner as described for chemical examination the stopper should be replaced quickly and tied down with oiled silk The sample should be sent to the laboratory at once as it must be examined as soon as possible

after collection If it must travel any distance the bottle should be packed in an ice box to prevent an increase in the number of micro organisms in the water

TO CALCULATE THE YIELD OF WATER

(a) **From a Well.**—The amount of water yielded by a well may be determined in the following way

Mark the normal level of the water and pump until this has gone down several feet if possible Mark the new level note the time and measure the distance between the two levels Record the time in hours required for the water to regain its normal level. Now let

D = difference in feet between the two levels
A = sectional area of the well
T = time in hours taken to regain normal level
G = yield in gallons per hour which we want to find

The formula is

$$G = \frac{D \times A \times 6.25}{T}$$

Example—How many gallons of water per hour may be obtained from a well of diameter 6 feet in which after the water level had been lowered by 4 feet normal level was regained in three hours?

Solution—The section of the well is a circle diameter 6 feet.

∴ the sectional area of the well

$$= \pi r^2 = 3.1416 \times 3 \times 3$$
$$= 28.2744 \text{ square feet}$$

From formula

$$G = \frac{D \times A \times 6.25}{T}$$
$$= \frac{4 \times 28.2744 \times 6.25}{3} = \frac{706.86}{3}$$
$$= 235.62 \text{ gallons per hour}$$

(b) **From a Piped Spring**—This may be found by taking the time needed to fill a vessel of known capacity

PART 1.—THE BUILDING OF A SIMPLE DWELLING

1 How to choose and improve building sites.

When selecting a site for a dwelling house, the chief points to be considered are its healthiness and general convenience

By healthiness is meant freedom from conditions which may be injurious or dangerous to health The conditions necessary to the healthiness of the site are as follows

(a) The soil should be porous and well drained. A [illegible]

The **ground water** should be at least 10 *feet* below the surface, otherwise its rise and fall will render the site damp and will force impure **ground air** into the building The ground water is found at various depths below the surface In some places it is only a foot, in others *it may be many hundreds of feet down In all* cases the water level rises and falls according to the presence or absence of heavy rain

The ground air is that which occupies the interstices of the soil above the water level When the water rises during heavy rain it pushes out the air and takes its place When the water recedes air again enters, and so there is a constant movement of ground water and ground air upwards and downwards

(b) The site should be clean. If the ground is polluted with refuse, or by leakages from drains or pit latrines, or by any other objectionable matter, the ground air will be very impure and, as it is constantly moving in and out of the ground, it may cause the site to be unhealthy

(c) The site should not be too low A site on rising ground is cooler and easier to drain than one in a

valley It is not, however best as a rule to build on the very top of a high hill as the house would be exposed to storms and would be too far from a water supply

(*d*) The site should be to the windward of any swamp which may be in the vicinity If the site is not to the windward of a close by swamp the house is likely to be infested with mosquitoes which are carried

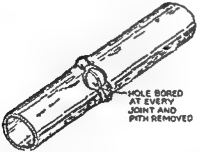

FIG 15 —A LARGE BAMBOO PREPARED FOR SUBSOIL DRAINAGE

Improvement of Sites.—(*a*) If a building must be erected on a water logged site the ground must first of all be drained This may be done by an arrangement of field pipes of french drains draining into a stream or other suitable place

Where large bamboos are available these can be used for this purpose if they are prepared as shown in Fig 15 Several bamboo pipes should be laid in each trench.

space, floor space, ventilation and lighting set out in Chapter I

Provision should be made for separate rooms for sleeping living cooking and the storage of foodstuffs. Facilities for bathing and means for the removal of refuse and waste water should also be provided

If the dwelling is to accommodate a family separate sleeping rooms should be provided for the parents and

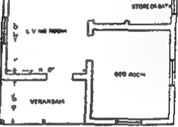

FIG 19 —PLAN OF A TWO-ROOMED HOUSE

for the children of either sex. Thus for a man and wife with male and female children at least three sleeping rooms are needed in addition to a living room bathroom and store

Figs 19, 20 and 21 show very simple types of dwellings which fulfil the above requirements (They are adapted from type drawings issued by the Kenya and Uganda Medical Departments)

3 *Setting out the Building*

Having chosen a suitable site and design, the next matter requiring attention is that of setting out the building on the site

The setting out of the house shown in Fig 20 will be taken as an example

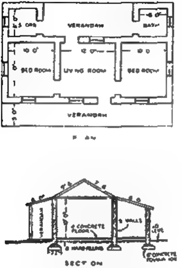

Fig 20—A Three Roomed House

Angles.—All the angles are right angles and may be set out by the method known as the 3-4 5 rule This is based on the fact that the square of the hypotenuse of a right angled triangle is equal to the sum of the squares of the two other sides.

This gives us the rule that if the two sides of a right angled triangle are 3 and 4 respectively, then the hypo-

Second Step—Find lines 1-3 and 2-4 at right angles to the base line by the 3-4 5 method, drive in pegs 3 and 4 and fix lines as before.

These three lines, thus fixed, form guide lines from which all the dimensions on the plan may be measured and set out

Third Step.—From pegs 1 and 3 measure 3 feet to the right and insert pegs 5 and 6 Fix line

Fourth Step.—Measure the length *of the front of* the building on the plan and set out this length from peg 5, obtaining the position of peg 7, take the same measurement from peg 6 and insert peg 8 Fix lines 5-6 and 7-8

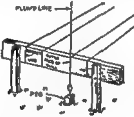

Fig 24—A Line Board

We now have the exact position of the extreme outside walls of the building

Fifth Step.—Now obtain the position of the remaining walls by measurement from the plan and insert pegs 9 20 in their proper order Put nails into all these, fix the lines and the outline of the building will be complete This is shown shaded in the figure

Note—All the pegs are 3 feet away from the wall faces, so that they may be out of the way of the work of excavation and of *building the walls*

The lines *ab*, *cd*, *ac*, *bd* show the position of the outside of the walls

Sixth Step.—The correctness of the setting out should be tested *by measuring the diagonals of the various*

rooms, first on the plan and then as set out If the two measurements tally in each case, then all is well.

Seventh Step.—Line Boards are erected over the pegs to show the positions of foundations, footings and walls (see Fig 24)

These are rough boards nailed across two stakes driven into the ground The position of the wall faces is taken from the pegs and marked on the board, the other lines needed are measured the correct distance from these and fixed when required

4 Foundations and Footings

Foundations.—The foundations of a building include the whole of that part which is below the ground—*i.e.*, a layer of concrete and the footings which rest upon it.

All brick or masonry walls must have foundations, and these should be designed to distribute the pressure, or weight, of the building over a greater area They also prevent unequal settlement, which would cause the walls to crack

As building proceeds from the bottom up the first step to be taken after the setting out is completed, is to dig trenches for the foundations. The next is to lay the concrete and on this to build the footings

The footings consist of a series of steps, each one projecting $2\frac{1}{4}$ inches beyond the course above, the lowest course being usually twice the width of the main wall. Thus below a 9 inch wall there will be two courses of footings and the bottom course will be 18 inches wide The concrete projects 4 inches on either side of the bottom course, thus extending further the pressure area

Fig 25 shows a cross-section of foundations for a 9 inch wall. The concrete is 6 inches thick

The Trenches for Foundations.—In the last paragraph we determined the width of the trench necessary for a 9 inch wall—namely 26 inches, made up as follows the lowest step of the footings 18 inches plus the 4 inch projection of concrete on each side equals 8 inches,

total 26 inches The depth will depend upon and vary with the nature of the ground surface.

In every case the walls must start upon a level foundation The bottom of the trench must be levelled by means of a spirit level, the use of which will be learned best by *practical work on the building*

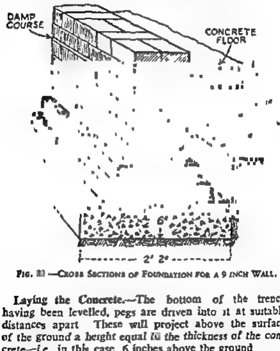

Fig. [illegible] —Cross Sections of Foundation for a 9 inch Wall.

Laying the Concrete.—The bottom of the trench having been levelled, pegs are driven into it at suitable distances apart These will project above the surface of the ground a height equal to *the thickness of the concrete*—*i e.*, in this case, 6 inches above the ground

The concrete is then put into the trench and beaten with *wood or iron rammers until it is level with the* top of the pegs When the concrete is quite hard it is ready to receive the first course of footings, which *is two bricks wide (see Figs 25 and 29)*

The making of concrete will be described in the section devoted to building materials No concrete should be made unless it is to be used at once as it is useless if it sets before being put into place

5 Bonds in Brickwork.

Definitions.—The **bond** is the way in which bricks are built into footings and walls so as to overlap in various ways thus ensuring strength and unity

There are several bonds but the commonest and best are the two known as **english bond** and **flemish bond** respectively

A stretcher is a brick laid with its length lying along the length of the wall

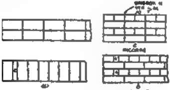

FIG 26—ENGLISH BOND

A header is a brick laid with its length across the thickness of the wall and its ends showing on the wall face

Mortar consists of lime and sand or of cement and sand It is used in building to bind together the stones or bricks and to fill up the spaces between them, so that water may not enter the walls It is also used for plastering or rendering the surfaces of walls floors and of concrete work (see section on Building Materials)

Bed joints are the horizontal joints in a wall The other joints are called **vertical joints**

Bricks are usually made 9 inches long 4½ inches wide and 3 inches thick

A closer is a brick cut lengthwise down the middle its size now being 9 inches long $2\frac{1}{4}$ inches wide and 3 inches thick Its use will be seen in the following figures

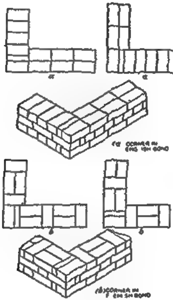

FIG. 27 —CORNERS IN ENGLISH AND IN FLEMISH BOND

Courses —Walls are built in horizontal rows of bricks each row having a bed joint of mortar between it and the one above These rows are called **courses.**

English bond —This is a method of laying bricks in

of a 9
ws the
which

are inserted next to the first brick in the header course so as to cause the vertical joints in the alternate courses to "break bond" If it were not for the closer, every second vertical joint of the header course would fall immediately over the vertical joint in the stretcher course as shown in Fig 26 (*c*) and the wall would consist of a number of piles of bricks not connected with each other by overlapping Fig 26 (*b*) shows the elevation of a wall in which the joints fall into the correct positions owing to the insertion of closers

Corners.—Where two walls meet at the corner of a building they must be properly connected or bonded together Fig 27 (*a*) shows plans of the two alternate courses—*i e*, of headers and stretchers—and a general view of the corner of a 9 inch wall built in english bond.

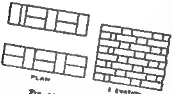

Fig 28.—Flemish Bond

Flemish Bond.—In this bond headers and stretchers are laid alternately in the same course Closers must be inserted next to the first header as in english bond. Fig 28 shows the alternate courses and the elevation of a 9 inch wall built in flemish bond

Fig 27 (*b*) shows plans and general view of a corner in flemish bond

Bond for Footings.—The bricks in footings should be laid with as many headers as possible to obtain greater strength

A 9 inch wall requires two courses of footings as shown in Fig 29

(b) A layer of felt treated with bitumen This may be used alone or better, laid on the top of a layer of cement mortar as described above

(c) A specially made damp-course material consisting of a layer of sheet lead between two layers of bitumenized felt ("Ledkore")

(d) A layer of sheet lead

(e) Other materials are often used in Europe, such as two layers of slate bedded in cement mortar, two courses of very hard and dense bricks in cement mortar, glazed stoneware tiles, and so on

Fig 25 shows the correct position of the damp proof course in relation to ground level and floor as described and as used for the three roomed house (Fig 20)

7 Roofs.

Definition—Pitch—A roof must be constructed with a slope in order to throw off the rain This slope is called the pitch of the roof It is described either by the number of degrees contained in the angle between the rafter and the springing line or by the proportion which the rise bears to the span—i e,

$$\text{pitch} = \frac{\text{rise}}{\text{span}}$$

Thus Fig 30 shows a roof whose sides slope at 45 degrees and whose rise is equal to half its span Such a *roof is described either as "a 45-degree pitch roof"* or as "a ½ pitch roof"

The minimum slope or pitch of a roof varies according to the kind of material used for covering The following are the minimum pitches which should be used for various roof coverings

Roofing Material	*Minimum Pitch*
Corrugated iron	12 degrees
Pan tiles	*33 degrees or ⅓-pitch*
Plain tiles	45 degrees or ½-pitch
Thatch	45 degrees or ½ pitch.

It will be noted that the more porous the material, the steeper the pitch. The object is that the greater part of the rainwater which falls on to the roof shall be thrown off and not be absorbed into the substance of the roof.

Rise—This is the vertical distance from the centre of the springing line to the apex of the roof (Fig 30) the rise corresponds to the altitude of the triangle

Span—This is the distance between the points of support of the roof usually the walls (Fig 30)

Springing line—This is an imaginary line taken horizontally across the points of support it corresponds to the base of the triangle (Fig 30).

Wall plates are lengths of timber laid on the top of the walls Their purpose is to provide a means of fixing the lower ends of the rafters and to distribute the weight of the roof evenly along the walls The sectional area of wall plates may be 4 by 2 inches or, better 4 by 3 inches (see Fig 36)

Rafters are the timbers which form the slopes of the roof These are fixed at the foot to the wall plates and the head to the ridge board (see Figs. 35 36 etc)

The ridge board runs lengthwise at the highest point or vertex of the roof Its purpose is to provide a method of fixing the heads of the rafters (see Figs 35, 36 etc).

The tie beam holds in the feet of the rafters and prevents them from spreading (see Fig 36)

Fig 30—A Half Pitch Roof

Stresses applied to Roofs.—A stress is a force applied to a body The principle stresses are tension shearing compression and cross or transverse stress.

Tension is caused by a tensile stress or pulling Two opposite forces are applied to a body in such a manner as to tend to stretch it or to break it by direct pulling—in the manner of the two teams pulling on a rope in

tug-of-war. A tie beam is subjected to tensile stress by the outward thrust of the rafters at each end of the beam [Fig 31 (*a*)]

Compression is a squeezing or crushing stress, such as one gets in the struts of a truss [Fig 31 (*c*)]

FIG 31 —STRESSES
The direction of the forces is shown by arrows

Cross-stress is a stress applied transversely or across a bar or beam, tending to bend it or to break it across [Fig 31 (*d*)]

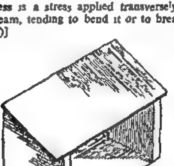

FIG 32 —A LEAN TO ROOF

Shearing Stress.—This tends to cut the fibres across or to cause them to slide upon each other The foot of a principal rafter tends to cause the fibres of the tie beam to slide upon each other [see Fig 31 (*b*) at (*a*)] The portion *shaded is liable to be "sheared off,"* or cut off, along the dotted line

Forms of Roof.—The simplest form of roof has only one slope, the ends rest on two parallel walls, one side of which is higher than the other In this way the roof gets the necessary slope, it is known as a lean-to roof (see Fig. 32)

Roofs with two main slopes are known as span roofs (see Fig 33) The triangular parts of the end walls are known as gables

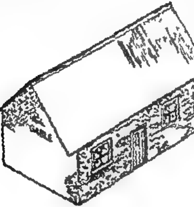

FIG. 33.—A SPAN ROOF (GABLED)

Another form of span roof has no gables the walls are carried up to the same height all round the building, and each end of the roof is sloped as shown in Fig 34

Such a roof is known as a hipped roof, and the rafters at the point of intersection of the four slopes are called hip rafters

A couple roof is a span roof formed by two rafters fixed in the ridge board and wall plate (see Fig 35) Such a roof should not be used except where the span is under 12 feet, as there is a tendency for the feet of the rafters to spread and to thrust out the walls, as shown by the dotted lines

The remedy for this defect is to add a tie beam which will hold in the feet of the rafters The roof then becomes a **couple-close roof** Such roofs are suitable for spans up to 16 feet (see Fig 36)

If the span is greater than 16 feet, the tie beam will

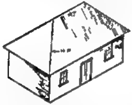

Fig 34 —A Hipped Roof

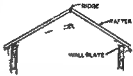

Fig 35 —A Couple Roof

have a tendency to bend downwards in the middle—that is to sag To prevent this a supporting member called the king post, is added The rafters being longer owing to the greater span will also tend to sag and must be supported by **struts.**

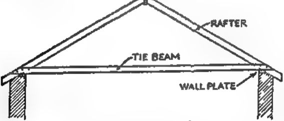

Fig 36 —A Couple Close Roof

We now get what is known as a **king post** roof which is suitable for a span not exceeding 30 feet (see Fig 37)

The King post Roof—This includes the roof trusses or principals the purlins and the common rafters

The truss or *principal* is the framework, composed of the tie beam, the principal rafters the king post and the struts.

Parts of a King-Post Truss (see Fig 37)—(1) **The Tie Beam.**—As far as the roof itself is concerned the object of the tie beam is to hold the feet of the principal rafters and to prevent them from spreading It is thus subjected to a pulling or tensile stress If it also carries the ceiling, it is subjected to a cross-stress in addition

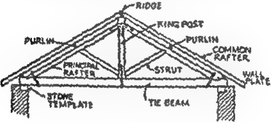

Fig 37—A King Post Roof

(2) The **king post** is a tie to hold up the centre of the tie beam and thus prevent it from sagging It is subjected to a tensile stress. Iron rods are sometimes used instead of tie beams and king posts

(3) The *principal rafters* are the sloping timbers of the truss. They are fixed at their upper ends to the king post and at their lower ends to the tie beam. They receive a cross stress and a [illegible]

(4) The [illegible]
them fro[illegible]
them by [illegible]
wind Th[illegible]ucture subjected in compression

After assembly, the trusses are placed across the walls, spaced about 6 to 10 feet apart, and the purlins are fixed in them

The **purlins** are timbers running longitudinally from truss to truss. and serve to support the common rafters

In order to prevent the inside of an iron roofed building being unduly affected by changes in the outside temperature, ceilings of wood or plaster may be provided in the rooms, together with plenty of ventilation both above and below the ceilings

Fixing Corrugated Iron Sheets.—These should be nailed to the purlins—which are spaced about 4 feet apart —with galvanized iron roofing nails made for the purpose The holes for the nails should always be made at the top of the corrugations, otherwise rainwater will run down through them and the result will be a leaky roof

In fixing the sheets, it is best to give a side lap equal to two corrugations and an end lap of not less than 4 inches

Ridge and hips are finished with specially shaped 6 feet lengths of galvanized iron (see ridge of roof in Fig 39)

Tiles—Tiles are made of a material similar to that used for bricks, and form one of the best roof coverings, Their advantages are, they are bad heat conductors they do not harbour vermin, they present a good appearance and their manufacture provides employment for local workmen Their disadvantages are they are not so easily transported as corrugated iron sheets, many may be broken in transit Skill is required for fixing, they are heavy and need strong roof framework to carry them, the cost of the building being therefore increased

There are two kinds of tiles in common use—**plain tiles** and **pan tiles**.

The **plain tile** is usually 10½ inches long by 6½ inches wide, and from ⅜ to ½ inch thick It is not made perfectly straight lengthways, but has a slight curve or camber, which allows the tail of one tile to fit tightly to the back of the one below it [see Fig 40 (*a*)] Tiles are usually laid on laths which are nailed to the common rafters

Terms used in Tile-laying—Nibs—A nib is a projection on the back of the top end of a tile by means of which it is hung on to the lath [Fig 40 (*a*)]

Lap (for Plain Tiles)—This is the distance by which the tail of one tile overlaps the head of the one in the second course below it [see Fig 40 (*b*)]

Gauge—This is the distance between the laths measured from the centre of one to the centre of the next [Fig 40 (*b*)]

Margin—This is the exposed part of each tile It is always the same length as the gauge [Fig 40 (*b*)]

Tile Laths or Battens.—These are narrow strips of wood usually 1½ inches wide by ½ inch thick, which are nailed at right angles to the rafters to support the tiles (see Figs 40 41 and 42)

Rule to calculate the gauge and margin (plain tiles)

$$\text{Gauge} = \frac{\text{length of tile lap}}{2}$$

Example—What is the gauge for laying 10½ × 6½ inches plain tiles to a lap of 2½ inches?

Solution—By the rule

$$\text{Gauge} = \frac{10\tfrac{1}{2}-2\tfrac{1}{2}\ \text{inches}}{2} = 4\ \text{inches}$$

—*i.e* the tile laths will be nailed on to the rafters at a distance of 4 inches apart measured from the centre of one lath to the centre of the next.

Laying the Tiles.—Tile laying begins at the eaves and is carried upwards to the ridge The first or lowest course consists of tiles of a different size from those used for the remainder of the roof their length being equal to the gauge plus the lap [see Fig 40 (*b*) and 41 (*a*)]

They are laid projecting over the fascia board ½ inch to 2 inches in order to cause the rainwater to fall into the eaves gutters Over this row tiles of ordinary size are laid so that in effect the lowest course is double [see Fig 40 (*b*)]

The fascia board is fixed higher than the top of the laths in order to give a tilt to this first double course This tilt makes the tail end of the second course fit tightly to the back of the tiles in the first [see Fig 40 (*b*)]

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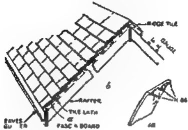


FIG 40 —A TILED ROOF

The ridge is covered with tiles of a special shape embedded in cement mortar [Fig 40 (b)] Similar tiles are used for the hips

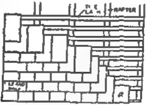


FIG 41 —PLAN OF PLAIN TILING

Pan tiles are curved and they differ from plain tiles in that, whereas plain tiles are laid in such a manner that there is a double thickness of tile all over the roof in the case of pan tiles there is only a single thickness except at the points where the laps occur It follows that the number of pan tiles required to cover any given roof area will be much less than the number of plain tiles needed for the same area

Pan tiles are usually 14 inches long by 9 inches wide and are given a side lap of 2 inches and an end lap of 3 to 4 inches

Lap for pan tiles is the distance by which a tile extends over the one immediately below it not, as in the case of plain tiles in the second course below

The gauge for pan tiles is length of tile minus the lap

Fig. 42 (*a*) shows a cross section of one form of pan tile showing side laps

Fig 42 (*b*) shows a longitudinal section showing end lap gauge and margin

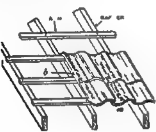


FIG 42—PAN TILES

These tiles when laid form a series of corrugations from ridge to eaves They are not laid double at the eaves as in the case with plain tiles

8 Floors.

Concrete Floors.—Floors should always be raised above the level of the outside ground and wherever possible should be constructed of hard, durable and easily washable material which will not harbour rats or insect vermin

The best material for floors in the tropics is concrete wrought to a smooth and level finish

Laying a Concrete Floor—The floor shown in the three-roomed house (Fig XII section) will be taken as an example

to give cross-ventilation, and that those of the central room give through ventilation.

The sizes of the windows should conform to the requirements of the local authority's rules In this case the outside rooms are 10 by 11 feet in area, and the central room is 12 by 11 feet

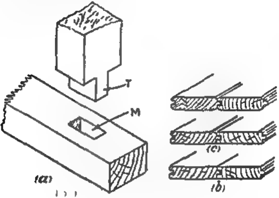


FIG 43 —JOINTS

Therefore the total window area for the outside rooms should be not less than $\frac{10 \times 11}{8} = 13\frac{3}{4}$ square feet.

For the central room the total window area should be not less than $\frac{12 \times 11}{8} = 16\frac{1}{2}$ square feet

square feet of window area

Casements.—The most commonly used type of window is called the **casement window**. It consists of a window frame with two glazed portions which meet in the centre and are hinged at the sides Fig 6 shows a window of this type

Doors.—The simplest type of door is one constructed with tongued and grooved boarding—called **matchboards**—which are held together by **ledges**. This is known as a **ledged and braced door**, and is quite suitable for the type of house shown in Fig 20

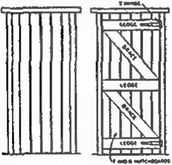


FIG 44 —LEDGED AND BRACED DOOR

Such a door is shown in Fig 44, with the names of the various parts indicated.

The ledges and braces are fixed on the inside of the door, and the braces are fixed so as to incline downwards

[illegible]

and be so placed as to conceal as much as possible of the room wh[illegible]

Door Frame—Doors are hung to their frames as shown in Fig 44, in this case the frame is constructed of 4 by 3 inches timber

Fig 45 (*a*) and (*b*) shows how a door frame is set in a wall, windows are set in the same way

Note that the frame in this case projects about ½ inch beyond the inside surface of the wall so that it will be flush with the finished surface after the plaster has been applied

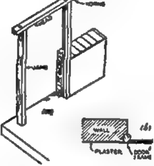


FIG 45 —SETTING A DOOR FRAME

The vertical timbers of the frame are called the jambs, and the horizontal piece at the top the head.

The head is morticed and the jambs have tenons When the head is in place, it should project 3 inches beyond the jambs on each side as shown in Fig 45 (a) the projections being known as horns, and their purpose being to fix the top part of the frame The door frames are placed in position and the walls are built round them, the horns being built into the walls The lower ends of the jambs are fixed to the concrete floor with iron dowels, these are pieces of ½ inch round iron bar, cut off about 4 inches long, 3 inches being inserted into the centre of the bottom of the jamb and 1 inch projecting into the concrete

The jambs may be fixed at other points along their length by long nails driven into pieces of wood, which are built into the bed joints of the wall for this purpose These pieces of wood are called pads, they should be of about the same thickness as the bed joint and should be made of seasoned wood, otherwise they will shrink and become loose

The best hinges for use on a ledged door are those known as T-hinges (see Fig 44)

10 Plastering.

Plastering means rendering the inside of the walls with a thin layer of mortar in order to obtain a smooth unbroken surface When used for exterior work in order to protect inferior brickwork, and so on, it is known as stucco work or rough cast.

Plaster may be applied to walls of stone, brick or concrete It may also be applied to a base of wooden or metal laths, as in the case of ceilings or partitions In the case of the brick or masonry walls these are left rough and the joints are raked out to about ½ inch from the surface, so that a "key" is formed to hold the plaster in position In the case of lath work, some of the plaster passes between the spaces and folds over on the inner side thus achieving the same end.

The mortar or plaster, as it is called may be made of lime and sand or of cement and sand

Lime Plaster—Lime plaster must be applied in at least two coats, the total thickness being ½ to ¾ inch The first coat is brought to a smooth and level surface and is left for two or three days While still soft it is scratched all over with diagonal grooves. These grooves provide a firm hold for the second coat, which is squeezed into them

First Coat.—The plaster for the first coat is known as **rough stuff**, and is composed of 1 part of lime to 2 or 3 parts of sand To this mixture must be added long ox hair, or fibre, to the extent of 1 pound to every 3 cubic feet of mortar The purpose of this is to bind the mortar together, lime mortar has not sufficient strength in itself This first coat is laid to a thickness of about ½ inch

Second Coat.—The second coat consists of 3 parts lime to 1 of fine sand. No hair is added if the plastering is to be finished in two coats. This coat is laid on after the first coat has dried or set, and should be about ⅛ to ¼ inch in thickness.

Cement Plaster.—Cement plaster may be finished in one coat, and no hair is required. The mortar may consist of cement 1 part and sand 3 or 4 parts, with sufficient water to make it into a stiff paste.

Rough Cast.—Rough cast is plaster used on exterior walls in order to improve their appearance or to protect porous building materials from the action of the weather.

It may consist of 1 part cement and 3 or 4 parts coarse sand applied in two coats, the second of which is thrown on with a trowel. This method of application gives the rough appearance from which the name rough cast is obtained.

11. Painting and Decorating.

Paint.—Paint is used not only to give a good appearance to buildings, but also to preserve the surfaces to which it is applied.

All paint is composed of two parts—**the pigment** and **the fluid medium.**

The pigment gives colour and body to the paint, and consists either of mineral oxides or of vegetable dyes.

The fluid medium is the liquid in which the pigment is dissolved. It is also termed the **vehicle**, because its purpose is to carry the pigment evenly over the surface to which it is applied. The fluid medium may be oil, in which case the paint is known as **oil paint**; or it may be water, in which case it is called **water paint.** Oil paint must be used when the paint is used as a preservative as well as a decoration. Water paints are used for decorative effects only. They have very little preservative value, [illegible] the appear-

[illegible] etc.

[illegible] is

[illegible] at

[illegible]

The following are the steps necessary for finishing new woodwork in three coats

The surface is dusted with a dusting brush. All knots are covered with a substance known as knotting, which prevents gum or sap exuding from them and spoiling the painted surface

The first coat of paint is then applied very thinly This is called the **priming coat.** Priming paint is usually a mixture of white lead and red lead in a fluid medium of 3 parts linseed oil and 1 part turpentine Its consistency should be quite thin, so that it may be readily absorbed by the pores of the wood. When thoroughly dry, the priming coat should be rubbed lightly with glass paper to give a smooth surface

All cracks, defective joints and other blemishes in the woodwork must now be stopped up with a paste known as putty This part of the work is called **stopping.** The putty must be forced into place with a knife and allowed to project above the surface a little until it begins to dry when it will harden and shrink a little It should then be levelled off with the knife and rubbed with glass paper to make it smooth

Note.—It is important to perform the stopping after and not before the priming coat has been applied

The second coat consists of the paint to be used for the third or final coat and should be spread thinly and evenly, when quite dry, it should be rubbed with glass paper, as was the priming coat.

The third coat should be applied carefully and evenly the brush being used very lightly in order that the finished surface may not present a streaky appearance

Application of Water Colours or Distemper.—These are used for wall surfaces, both interior and exterior, and should be applied with large flat brushes made for the purpose, so that the paint may be spread as rapidly as possible over a large surface If one part of the wall is allowed to dry before the rest is painted, the finished result will show marks and patches where the two sections join.

Limewash is a mixture of lime or white chalk with water The materials should be mixed to a smooth paste allowed to stand for some time, then diluted with water to the necessary consistency.

To prevent the limewash rubbing off when dry, size (fine liquid glue) should be added to the mixture, the glue will hold the lime to the wall after the water has evaporated The same end may be achieved by adding 1 tablespoonful of powdered alum to 1 gallon of whitewash

If the surface to which either distemper or lime wash is to be applied consists of new plaster, a coat of size diluted with hot water should be laid on while still hot This will fill up the pores in the plaster and prevent the paint from soaking into it

Outside Work.—*When limewash is to be used for out* ... [illegible] ... ther of the

[illegible]

(2) Prepare the following

(a) 62 pounds of quicklime mixed with [illegible] gallons of hot water

(b) 12 gallons of rock salt dissolved in 6 gallons of hot water.

(c) 6 pounds of Portland cement.

Put (b) into (a) and mix well Now add the cement and stir until thoroughly mixed

PART II

1 Causes and Cure of Dampness in the Walls of a House.

As we have seen, it is necessary to take precautions against the rise of moisture in the walls of a house There are many reasons for this A damp house [illegible] ... [illegible] ... and the wood- [illegible] ... it ... ne permanently damp, the possibility must be guarded

against while building it. Most township authorities have power to insist that every wall of brick, stone or oncrete shall have a damp-proof course made of durable aterial impervious to moisture This course must be elow the ground level and at least 6 inches above the rface of the ground (see Fig 25)

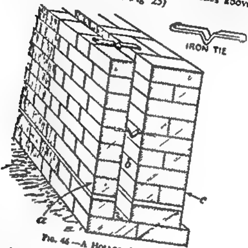


Fig. 46 —A Hollow Wall

Principal Causes, Prevention and Remedies of Dampness—Cause 1—(a) The walls may be built of very porous material, such as badly burned bricks or inferior concrete blocks, these are most likely to be the cause of dampness in walls exposed to driving rains

(b) Poor quality mortar may have been used, this crumbles away and conducts moisture to the inside of the walls

Prevention—Dampness arising from the above causes may be prevented by

(a) The use of better-class materials.

(b) The construction of hollow walls. Fig 46 shows

a section of a hollow or cavity wall in brick work The thin outer portion of the wall (*a*) is tied or bonded to the main wall (*c*) by iron ties spaced every 24 inches in each fourth course The cavity (*b*) is 3 inches wide and must be protected while the wall is being built from the ingress of mortar or broken bricks, which would form a bridge and would conduct moisture to the inner wall

(c) Fixing tile laths to the walls and hanging them with plain tiles in a manner similar to that employed in roofing This is known as **tile-hanging**

(d) Rendering the exterior surface of the walls in cement mortar or rough cast

(e) Painting the exterior surfaces of the walls with oil paint or with one of the waterproofing liquids sold for the purpose

(f) Applying a coat of hot asphalt This has not a pleasing appearance

(g) The following method which has given good results A solution of soap in boiling water is applied whilst still very hot this is allowed to dry thoroughly and then a coat of alum dissolved in water is put on The alum and soap combine to form an insoluble compound in the pores of the bricks or other materials and make the wall waterproof

Remedies for Dampness arising from Cause 1 (a)— The above methods (c) to (g) may also be used as remedies in the case of walls which have proved to be damp Except in the case of (d) the work should be carried out during a spell of dry weather so that the walls may be as dry as possible at the time of treatment

Remedy for Dampness arising from Cause 1 (b) — If the mortar is at fault the joints should be raked out to a depth of about ½ inch and the work repointed in good cement mortar

Cause 2 —The Damp proof Course —The damp proof course may have been omitted or may have been constructed of inferior or unsuitable materials

Remedy —A new damp course must be inserted This can be done by removing a few feet of bricks or concrete blocks at a time inserting the damp course and

then making good the structure of the wall. This process is repeated until the whole of the new damp course has been inserted

Cause 3.—Unprotected Parapet Walls.—A parapet wall is one which runs up above the roof, as shown in Fig 47, and into the top of which rain will soak, causing dampness in the whole of the wall unless precautions are taken

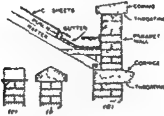


Fig 47 —Protection of a Parapet Wall

In the sketch the top of the wall is protected by a coping or cap, which may be of stone, concrete, or good bricks set on edge and laid in cement mortar Fig 47 [illegible] the wall (see Fig 47)

Behind the parapet wall is a gutter, which receives the water from the roof, it is shown made of boarding covered with galvanized sheet iron as in this case the roof is covered with corrugated iron sheets

Note that the metal is turned up against the wall the turned up portion being held in place by another piece of metal which has been inserted into a bed joint of the wall and turned down. This piece of metal is called an

apron, and is marked in the sketch The wall side of the gutter is not fixed in any other way, so that the metal of which it is composed may be free to expand and contract without buckling

On the other side the gutter is fixed with nails to the purlin, which is shaped as shown in the sketch so that its upper edge is reduced where it comes into contact with the corrugated iron sheets, thus lessening the possibility of water passing between the wood and the iron by capillary attraction

Other materials, such as sheet lead or asphalt may be used for gutters in a similar manner, they are generally more expensive

Cause 4—Defective roofs, rainwater pipes and gutters

Remedy.—These should be renewed.

Cause 5.—Deposits of materials, earth or rubbish against the walls, and extending to a height above that of the damp course

Remedy.—The ground surrounding the house should be kept clean and free from such deposits

Cause 6—Large trees surrounding the house attracting moisture and reducing the drying action of the sun and wind

Remedy—These should be cut out, so that the house *stands in a clear space*

2 Building Materials

Asphalt and Bitumen—Asphalt and bitumen are synonymous names for a black, tar like, mouldable substance which is found in various parts of the world in a natural state It is also manufactured from petroleum tar and other substances

The name asphalt is, however, more commonly used to designate rock asphalt, a mixture of limestone or sand stone with bitumen This mixture also occurs in a natural state but generally it is manufactured and is the tar like substance which is commonly used for surfacing roads Rock asphalt is sold in blocks, which are melted by heat and applied to the surface while in liquid form When cooled it hardens, but does not become brittle

It is water proof, and is valuable for covering flat roofs, for floors that require frequent washing, as in slaughter houses, and for waterproofing tanks and cisterns It is particularly valuable for damp proof courses, because not only is it waterproof, but it is to some extent pliable and does not fracture

For most purposes it is applied in two layers to a thick ness of ¼ to ½ inch.

Asbestos.—Asbestos is a white or grey fibrous material which is very soft when powdered It is incombustible It is obtained from mines, and is manufactured into sheets or rolls for covering roofs, ceilings and walls of buildings

Bricks.—Bricks may be unburned or burned, and may be either machine or hand made As bricks vary enormously in their nature and quality according to the kind of earth from which they are made, and also to their method of manufacture, we shall first set down the **characteristics of good bricks.**

(a) The [illegible]

four hours

(d) They should be free from cracks and small stones

(e) They should emit a metallic sound when two are struck together

(f) They should be strong and not easily broken with a hammer or trowel.

It is obvious that most of the above qualities apply to burned bricks but the unburned variety has its uses in places where fuel is expensive and difficult to obtain

Brick Earth.—It is very important that a suitable earth should be chosen, and samples should be taken and thoroughly tested before brick making is started on any scale

The most suitable kind of earth is usually found below the surface of the ground, near rivers and swamps. Specimen bricks should be made from earth taken from various likely places and should then be put to dry in

the shade The earth finally chosen should be one which makes a brick that does not crack in the drying and which sets firm and hard Note that if the bricks are dried too quickly by being exposed to hot drying winds they will crack even if the earth of which they are made is a suitable one

If cracks appear which are not due to faulty drying the earth is unsuitable if of too a clayey a nature, it may be improved by being well mixed with earth of a lighter sandier nature

bottom fixed to the mould

A suitable earth having been chosen and tested all small stones should be removed, this is important, as stones cause cracks and faults in the finished bricks

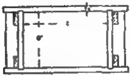
The earth should then be mixed with water and prepared by treading and kneading until it is of such a consistency that the bricks slip easily from the moulds

The plastic earth should be rammed into the moulds

handle attached to it [see Fig 48 (a)] The brick

harbour ticks and other vermin In these two respects they are no better than mud and pole construction and where fuel is available it is infinitely better to burn the bricks The one advantage of unburned bricks is that in a timberless country the amount of wood used in the construction of a building can be reduced to a minimum by their use

Burned Bricks.—In the making of these the same methods are used as for unburned bricks except that (1) the sample bricks, after drying should be placed in a heated oven and left for several days in order to test the burning quality of the earth, (2) the moulds used are generally of a different size—viz., 9¾ inches long 4¾ inches wide and 3¼ inches deep inside measurement. Thus



PLAN OF MOULD FOR UNBURNED BRICKS

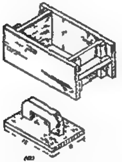


Fig 48 — Brick Moulds

gives a brick 9 inches long by 4½ inches wide by 3 inches deep when burned when bricks are burned they shrink a little in all directions The moulds are made in the same manner (see Fig 48)

When a sufficient number of bricks have been made and dried they are burned in the following manner It is called clamp burning

Clamp Burning—Building the Clamp.—Fig 49 shows how the stack or clamp is built of the actual bricks which are to be burned About 6,000 bricks would be burned in a clamp of the dimensions indicated, but it might be carried considerably higher, so that more bricks could be burned at one time if desired

A piece of ground is cleared and made quite level th first course is then laid as shown in Plan A each bric being separated from its neighbour by a space the thick ness of a man's finger (*i e* about ½ inch) and being laid with its narrow side uppermost The second course is laid as shown in Plan B and then another course as in Plan A Note that four fireholes have been formed equal in width to the length of two bricks.

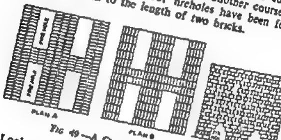


Fig 49 —A Clamp for Burning Bricks

Look at the elevation and you will see that the process of bridging over the top of the fireholes starts at the fourth course and is completed in the sixth course From the seventh course onwards the bricks are laid in alter native courses of headers and stretchers over the fi area of the clamp Each brick must have a space betwee it and the next so that the heat may circulate throughou the clamp This is necessary as otherwise it would be impossible to have all the bricks properly burned

The four sides of the clamp are now plastered with mud in order to keep in the heat. The top is covered with loose dry earth one row of bricks across the centre being left uncovered for the first few days of firing so that the steam caused by moisture in the bricks may escape

Firing the Clamp.—Each thousand bricks needs about one ton of firewood, which should not be cut or split into small pieces otherwise the fire will burn too rapidly and fiercely The whole process of burning will take about four or five days

On the first day small slow fires are lighted in the four fireholes The bricks in the clamp must be heated gradually because if the fire is too hot at first many bricks will be destroyed

The fires are kept burning night and day the heat being increased each day until the bricks which were left uncovered at the top of the clamp become red hot. These are now covered with loose earth like the remainder

The firing now ceases and the fireholes are closed with bricks and mud The heat is thus retained in the clamp and the bricks will continue to burn for some days When the clamp is quite cold it may be demolished and the finished bricks stacked carefully in lots according to their quality

It is usually found that the bricks nearest to the fire holes are over burned, while those on the outside of the clamp are under burned

If the clamp cannot be protected against rain the burning must be done in dry weather otherwise the bricks may be destroyed

If possible a roof of corrugated iron should be erected on poles over the place where the clamp is to be built this should be several feet higher than the clamp; otherwise it is liable to be destroyed by fire The iron sheets used for this purpose may afterwards be used on the building to be erected.

Cement.—The best kind is that known as Portland cement. It is made from chalk and clay accurately proportioned and mixed together in a slurry mill until the mixture is of a uniform composition This is then burned in an exceedingly hot kiln until clinkers are formed these are then ground to a powder of such a degree of fineness that 82 per cent. of it will pass through

a sieve having 32 400 holes to the square inch This powder is the finished product

When cement powder is mixed with water to form a paste chemical action is set up as the water combines with the cement and the paste begins to harden This is *known as the initial set and should not be interrupted,* otherwise the cement loses a great deal of its strength and, in fact may never harden or set properly For this reason cement concrete or cement mortar should only *be prepared in such quantities as can be used immedi*ately, before the initial set has begun

Cement Concrete—This is a mixture of Portland cement, sand and broken brick broken stone or other similar hard material The broken bricks or stones form what is known as the aggregate

The proportions of materials vary according to the purpose for which the concrete is intended They are as follows

Parts by Volume

	Cement	*Sand*	*Aggregate*
For foundations walls and floors	1	3	6
Water tanks *reinforced work*	*1*	2	*4*
Rough work covering sites etc	1	4	8

Mixing Concrete by Hand—In making concrete a *clean aggregate the individual fragments of which vary* in size from that of a grain of maize to that of a hen s egg is required The sand used must be clean and free from earth or vegetable matter The materials should be measured and spread on a clean wooden platform or other smooth hard surface in the following order first the sand spread in an even layer and next the cement The whole should now be turned over with a clean dry shovel three or four times or until the two ingredients are thoroughly mixed which will be when the mixture is
... The aggregate is now thrown over
... times
... that the

Water should now be added by sprinkling from a can provided with a rose and the concrete should be thoroughly mixed The process is complete when the concrete has become a slushy mixture which when in place is almost strong enough to bear the weight of a man and which should be sufficiently wet to show water on the surface when it is well rammed into position with iron or wooden rammers

The concrete must not be disturbed after it has been rammed into position and has begun to set. If disturbance does take place the quality of the work will be seriously affected. When in place the surface should be protected from the direct rays of the sun and should be watered daily for one week, two weeks would be better if circumstances permit.

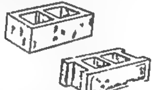


FIG. 50 —HOLLOW CONCRETE BLOCKS

Concrete Blocks or Moulded Concrete.—Concrete may be cast in moulds similar to those used for bricks but so constructed that they may be taken apart and removed without disturbing the concrete after it has begun to set.

By the use of appropriate moulds many parts of the structure of a building may be cast in concrete Such are artificial stone blocks of all kinds, sills lintels plinths columns paving slabs, pipes steps tiles and arch stones Even the walls of buildings may be so cast between "shutters," which are moved upwards as the height of the wall increases.

Concrete building blocks are usually made hollow and special hand machines may be obtained for the purpose Hollow blocks are lighter and much less

gations are formed either by passing the flat sheets through grooved rollers or by pressing them

Corrugated iron sheets are obtainable in sizes from 6 to 10 feet long and about 2 feet 2 inches wide They vary in thickness or gauge, as it is called, No 24 gauge is a useful weight for general work The lower the gauge the thicker the sheet

The following table shows the approximate number of 10-feet sheets of various gauges per ton The corresponding number of sheets of other lengths may be calculated by simple proportion

No [illegible] gauge	42	10-feet sheets per ton
No 20 gauge	53	" " "
No 22 gauge	67	" " "
No 24 gauge	[illegible]	" " "
No 26 gauge	108	" " "
No 28 gauge	120	" " "

[illegible]

ing material water is added the quicklime thus becoming slaked

Slaked lime is used mixed with sand in the same way

[illegible]

condensation moisture forms on its surface, as it sometimes does on that of cement mortar

[illegible]

Sheet lead is designated by its weight per square foot—e g , sheet lead weighing 6 pounds per square foot is called **6 pound sheet lead.**

Lead is used for gutters, flashings, flat roofs cisterns damp courses and pipes It is expensive (its weight makes the freight charges very high), and for this reason and the fact that it expands readily on exposure to heat it is not in very general use in the tropics.

Lead wool consists of fine threads of lead twisted to the form of a rope It is used instead of molten lead for caulked lead joints in iron pipes.

Red lead and white lead are pigments used in the manufacture of paints and for jointing metal ware

PART III.—SIMPLE QUANTITIES AND ESTIMATING.

1 Concrete, Plaster and Mortar

To estimate Amount of Concrete required—We are taking for an example the three roomed house (Fig 20 p 71), and will proceed to estimate the amount of concrete required for the foundations.

Refer to the plan and section mentioned above, from the section we find that the concrete for the foundations should be [illegible] inches thick and 2 feet 2 inches wide the various lengths may be taken from the plan For ease in measuring it is advisable to make a rough foundation plan, remembering that the walls run along in the centre of the concrete See Fig 51, in which the concrete is shown by dotted lines

On examining the sketch you will find that the space to be filled with concrete is made up of twelve rectangles each of which is 2 feet 2 inches wide, the length being

2 lengths of 36 feet 9 inches	=	73 feet 6 inches
4 lengths of 9 feet 7 inches	=	38 feet 4 inches
4 lengths of 6 feet 9 inches	=	27 feet 0 inches
2 lengths of 4 feet 9 inches	=	9 feet 6 inches
Total length of concrete	=	148 feet 4 inches

Using the above table

Amount of cement required is 13 pounds × 160 7
Amount of sand required is 0 42 cu. ft. = 160 7
Amount of aggregate required is 0 84 cu ft. × 160 7

∴ Cost of cement at 7 shillings per 100 pounds –

$$\frac{13 \times 160\ 7 \times 7}{100} = 146\ 25 \text{ shillings}$$

Cost of sand at 20 cents per cubic foot = 0 42 × 160 7 × 0 20 = 13 50 shillings

Cost of aggregate at 50 cents per cubic foot = 0 84 × 160 7 × 0 5 = 67 49 shillings

Total cost of materials for concrete – 227 24 shillings

2 Bricks, Stone and Concrete Blocks

To find the number of bricks required for a simple building the volume of the walls and footings may be . The ... ngs of ... or the ... ng 20 ... bricks ... of the walls include two courses below ground level (2) the number of bricks needed for the footings The sum of these two quantities gives us the total number of bricks required

(1) (*a*) Refer to plan and obtain the total length of the walls *allowing 9 inches for thickness* We get $(2 \times 35) + (4 \times 11) + (4 \times 6) + (2 \times 7\ 5) = 153$ feet

(*b*) Refer to section and note that the total height of the walls is 11 feet 4 inches

(*c*) Note that the thickness of the walls is 9 inches

From (*a*) (*b*) and (*c*) volume of walls $= 153 \times 11\frac{1}{3} \times \frac{3}{4}$ feet $= \frac{2601}{2}$ cubic feet

A brick measures $9 \times 4\frac{1}{2} \times 3$ inches

∴ Volume of a brick $\frac{3}{4} \times \frac{3}{8} \times \frac{1}{4} = \frac{9}{128}$ cubic feet

$$\frac{\text{Volume of walls}}{\text{Volume of a brick}} = \text{number of bricks in walls}$$

$$\text{Number of bricks in walls} = \frac{2601 \times 128}{2 \times 9} = 18{,}496$$

(2) There are two courses in the footings—one is $13\frac{1}{2}$ inches wide and the other is 18 inches wide

(a) Average width of footings =

$$\frac{13.5 + 18}{2} = 15.75 \text{ inches}$$

(b) Height of footings = 2 courses = 6 inches

(c) Length of footings = length of walls = 153 feet

From (a) (b) and (c) volume of footings =

$$153 \text{ feet} \times \tfrac{1}{2} \text{ foot} \times \frac{15.75}{12} = \frac{3213}{32} \text{ cubic feet}$$

$$\frac{\text{Volume of footings}}{\text{Volume of a brick}} = \text{number of bricks in footings}$$

$$= \frac{3213 \times 128}{32 \times 9} = 1\,428 \text{ bricks}$$

Total number of bricks required = number of bricks in walls + number of bricks in footings = 18 496 + 1 428 = 19,924   Say 20 000 bricks

Note.—Window and door openings have been included in the calculation the extra bricks allow for losses due to cutting and waste

Mortar—Rules.—1 Allow 1 cubic foot of mortar for every sixty bricks

2. Amount of lime mortar produced = lime and sand − 25 per cent.

3 Amount of cement mortar produced = cement and sand − 17 per cent.

Example.—If 20 000 bricks are needed to build the three-roomed house what will be the cost of the cement mortar 1 3 for the brickwork? (cement at 7 shillings per cubic foot and sand at 20 cents per cubic foot)

Using the above table

Amount of cement required is 13 pounds × 160·7

Amount of sand required is 0·42 cu. [redacted] × 160·7

Amount of aggregate required [redacted] 0·84 cu ft. × 160·7

∴ Cost of cement at 7 shillings per 100 pounds = $\frac{13 \times 160{\cdot}7 \times 7}{100} = 146{\cdot}25$ shillings

Cost of sand at 20 cents per cubic foot = 0·42 × 160·7 × 0·20 = 13·50 shillings

Cost of aggregate at 50 cents per cubic foot = 0·84 × 160·7 × 0·5 = 67·49 shillings

Total cost of materials for concrete = 227·24 shillings

2 Bricks, Stone and Concrete Blocks.

To find the number of bricks required for a simple building the volume of the walls and footings may be calculated and divided by the volume of one brick. The same method [redacted] applicable in the case of buildings of stone or of concrete blocks.

Example —Find the number of bricks required for the building of the three roomed house shown in Fig [redacted]

Solution —We calculate (1) the number of bricks needed *for the walls less footings—i e the height of the walls* include two courses below ground level (2) the number of bricks needed for the footings The sum of these two quantities gives us the total number of bricks required.

(1) (*a*) Refer to plan and obtain the total length of the walls allowing 9 inches for thickness We get $(2 \times 35) + (4 \times 11) + (4 \times$ [redacted] $) + (2 \times 7{\cdot}5) = 153$ feet

(*b*) Refer to section and note that the total height of the walls is 11 feet 4 inches

(*c*) Note that the thickness of the walls is 9 inches

From (*a*), (*b*) and (*c*), volume of walls $= 153 \times 11\frac{1}{3} \times \frac{3}{4}$ feet $= \frac{2601}{2}$ cubic feet

A brick measures $9 \times 4\frac{1}{2} \times 3$ inches

∴ Volume of a brick $\frac{3}{4} \times \frac{3}{8} \times \frac{1}{4} = \frac{9}{128}$ cubic feet

The formula used is
Area of roof $= 2\ l \times L$
where l = length of rafter (plus overhang, if any)
L = length of eaves

Example—How many plain tiles laid at a 4-inch gauge, would be required to cover the roof of the three roomed house Fig 20? (size of tiles $10\frac{1}{2} \times 6$ inches.)

Solution—Refer to plan and section and take off length of rafters and eaves—*i e*

Length of rafters $= l = 7.5$ feet
Length of eaves $= L = 37$ feet.
Length of rafters of front verandah = 6 feet
Length of rafters of back verandah = 8 feet

(*a*) Total area of roof =

area of main roof	+	area of front verandah roof	+	area of back verandah roof	=
$2\ l \times L$	+	$l \times L$	+	$l \times L$	=
$2 \times 7.5 \times 37$	+	6×37	+	8×37	=

$37\,(15 + 6 + 8)$ square feet $= 37 \times 29 = 1{,}073$ square feet.

(*b*) Number of plain tiles needed =

$$\frac{\text{area of roof}}{\text{margin} \times \text{width of tile}}$$

Margin $= \frac{1}{3}$ foot, width of tile $= 6$ inches $= \frac{1}{2}$ foot

∴ Number of plain tiles needed =

$$\frac{1073}{\frac{1}{3} \times \frac{1}{2}} = 1\,073 \times 6 = 6{,}438 \text{ tiles}$$

Corrugated Iron Sheets—The first step to be taken when estimating the number of corrugated iron sheets needed for a roof is to ascertain what length will be required these may vary on different parts of the roof

To do this make an accurate drawing of the section of the roof to a fairly large scale (*i e*, ½ or ¼ inch = 1 foot) From this the length of sheet required may be taken by measurement

The number of sheets needed is got by dividing the length of the eaves by the width of the exposed portion of a sheet—*i e* the width of a sheet minus the side lap For roofing work a side lap of two corrugations—*i e*,

about 4 inches—should be given As sheets are made 2 feet 2 inches wide (as a rule) the exposed portion of the sheet is then 2 feet 2 inches − 4 inches = 1 foot 10 inches

Example.—What number and lengths of corrugated iron sheets would be needed to cover the roof of the three roomed house (Fig 20)?

Solution—(*a*) By measurement from the section we find that three slopes need 8 feet sheets and one slope needs 6 feet sheets Therefore we need sheets of two lengths—8 feet and 6 feet

(*b*) By measurement from plan the eaves are 37 feet long On each slope number of sheets required =

$$\frac{\text{length of eaves}}{\text{exposed portion of sheet}}$$

Exposed portion of sheet = width of sheet − side lap

= 2 feet 2 inches − 4 inches

= 1 foot 10 inches = $1\frac{5}{6}$ feet

(1) Number of 8 feet sheets

$$3 \times \frac{37}{1\frac{5}{6}} = 60.5 \text{ — say } 61 \text{ sheets}$$

(2) Number of 6-feet sheets =

$$\frac{37}{1\frac{5}{6}} = 20.1 \text{ — say } 20 \text{ sheets}$$

4 Painting.

It is difficult to estimate for painting work owing to the varied nature of the work

For rough estimating the following table may be used Note that the amount of paint needed for each successive coat is less than for the previous one

Painting on Wood.

First coat 1 pound of paint will cover about 4 square yards

Second coat 1 pound of paint will cover about 5 square yards

19 How would you calculate the area of (1) a hipped roof, (2) a gabled roof? Illustrate by sketches

20 Describe fully, giving an example, the method of estimating the number of corrugated iron sheets needed for a roof What is the exposed portion of a sheet?

CHAPTER IV

REFUSE DISPOSAL AND HOUSE DRAINAGE

REFUSE DISPOSAL

The collection and disposal of house refuse and excremental matter is a very important part of the work of all who are engaged in sanitation it is the first problem which must be tackled in any district, and the success of any further health measures introduced will depend to a large extent upon the efficiency with which it is solved.

House refuse includes waste vegetable and animal matter, ashes, tins, rags, broken bottles, paper and so on

Excremental matter consists of fæces and urine

Methods of collection and disposal vary according to local conditions but whatever the method adopted may be, no **nuisance** must be caused during storage, collection, or final disposal

Nuisances in this connection include conditions which are offensive or likely to be injurious or dangerous to health, such as bad smells fly breeding attraction of rats and other vermin mosquito breeding and the spread of infectious diseases

Disposal of House Refuse.

In towns, house refuse may be dealt with as follows

1 Every householder must provide himself with a sanitary dustbin This is a cylindrical receptacle of galvanized iron, about 18 inches in diameter and [illegible] feet [illegible] inches high having an effective capacity of about 4 cubic feet, it has a tightly fitting lid which is capable

of keeping out the rain and preventing the escape of offensive smells This should be kept in a shady place, in the open, which is convenient for the kitchen from which most of the refuse comes Any waste matter which can be burned on the kitchen fire should be so dealt with, the remainder being placed in the bin

2. At regular intervals the bin is emptied by the "dustmen" employed by the township authority into specially constructed carts or lorries, and the refuse is taken away to the place of disposal

3 The ultimate disposal of the refuse may be carried out by incineration or by tipping, or, if the town is near to the sea, it may be put into barges, taken out to sea and dumped in a suitable place

Incineration or Burning.—For the disposal of the refuse of a large town this is the method least likely to give rise to nuisance if the destructor is efficient and situated in a suitable place Such a destructor is a large and expensive apparatus and cannot be adequately described here

Tipping—This consists of tipping the refuse on to waste land or into disused murram pits or quarries The advantages of this method are

1 There is no large initial outlay for the purchase of an incinerator
2 Low lying land and holes may be filled in and made useful.

The disadvantages are that the following nuisances may arise if proper care is not taken

1 Flies and rats may be attracted and breed in large numbers
2 The refuse may catch fire and create smoke and dust.
3 Paper and other light refuse may be blown about and cause untidiness
4 Wells and other sources of water supply may be contaminated In order to prevent the occurrence of the above nuisances a system known as "controlled tipping" is adopted

2. Each day enough dry and easily burned refuse should be sorted out and used for starting the fire When necessary, a little dry grass or wood may be ued for this purpose This dry material is placed on the firebars of the incinerator

3 The drier portion of the remainder of the refuse is now put into the incinerator and the damper portion put on top

4 The fire is now lighted, the lower and drier part of the refuse burns and generates heat, which dries the upper damp layer, this in turn catches fire and the whole mass is reduced to ashes

5 When all the refuse has been burned, the ashes should be removed and the incinerator prepared for the work of the next day

The ashes are quite harmless They do not contain any matter which can putrefy and smell badly, nor do they attract rats and flies They may be dug into the soil of gardens with advantage, as they contain materials which are useful as fertilizer and plant food

Conversion into Manure—This method of disposal *for house refuse is very suitable for country districts* as it not only provides an efficient means of disposal, but the manure obtained as a result of the process is a valuable aid in the cultivation of farm crops There are *two ways of working this system*

1 **The Manure Pit.**—Each house in a village has its own manure pit which is a trench 6 feet wide 3 feet deep, and as long as may be necessary Into this all the house refuse, banana skins, waste food of all kinds yard *sweepings fowl manure goat manure, weeds, grass* clippings and so on are thrown At the end of each day the surface of the refuse is covered with a layer of soil 6 inches thick As the organic matter in the pit decomposes heat is generated and this will kill many of such fly larvæ as may hatch out. When decomposition is complete, the mould forms a valuable fertilizer which should be dug into the ground when it is being prepared *for crops* The *nitrogenous part* of the mould acts as a plant food, while the non nitrogenous matter provides

humus, which conserves the nitrogen and moisture in the soil.

2. The Indore Process.—This is a more elaborate working-out of the above system, and includes the disposal of night soil as well as of house refuse It has been used with success for the disposal of night soil and house refuse in several large towns in India. It may be carried out as follows

The disposal ground should be outside the village, but not too far away from it, otherwise carting expenses will

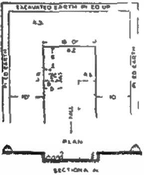


Fig 53—A Trench for Indore Process

be heavy A trench 15 feet wide, 2 feet deep, and as long as is necessary is prepared the bottom of the trench should have a fall towards one end in order that storm water may be discharged from it The excavated earth is piled up across the higher end and along both sides of the trench at a distance of 10 feet from its edge (see Fig 53)

Charging—A vacant space of 6 feet in length is left at the higher end of the trench (A2), and charging is begun on a section 5 feet across the trench and 4 feet along its side Refuse is spread evenly over this section (marked A in the figure) to a depth of about 4 inches

Collection.—*The best system of collection* is that known as the double bucket system. Two buckets are provided for each latrine. These are specially made for the purpose and have tightly fitting lids, which are removed when the bucket is placed in the latrine. The sweepers remove the used bucket, over which they place the lid, and replace it by a clean one. The used buckets and contents are taken in specially constructed carts to the disposal place, where they are emptied, washed and made ready for use the following night.

Disposal.—The Indore system, described above, may be used or night soil alone may be disposed of by a system of trenching. A certain area of ground well away from the town and from any water supply should be set aside for this purpose. Trenches about 2 feet [illegible]

is necessary at the disposal place to prevent any fly-breeding or other nuisance arising from carelessness in tipping or in covering the night soil.

Exercises.

1 *Describe fully a system of disposal for house refuse which you would recommend for adoption in a large township*

2 Describe the method of refuse disposal known as *"controlled tipping," indicating what you consider* [illegible]

3 Sk[illegible]

estimate the size of such an incinerator? State how it should be managed in order to obtain good results

4 Describe the "Indore" process of combined house refuse and night soil disposal. What are the advantages claimed for the above system?

5 Describe how a pit latrine should be constructed (a) of temporary materials (b) of permanent materials Sketch each type clearly showing the pit and quoting all dimensions

6 Sketch and describe a good type of bucket latrine

7 What is meant by the "dry conservancy system" of night soil disposal? What steps should be taken to ensure that no nuisance will arise from the working of this system?

8 Describe what you consider to be a good method for the collection and disposal of the contents of bucket latrines (a) in a town (b) in a country hospital or other similar institution

The Water Carriage System.—Under this system the excreta are deposited directly into properly constructed sanitary fittings, and are then carried away by water through drains and sewers to the disposal place

A **drain** is a system of pipes used for the drainage of one building only or of a number of buildings situated within the same plot It is the property of the owner of the building or buildings

A **sewer** is a larger drain and is usually the property of the township authority Private drains are connected to the sewer which carries the drainage (or sewage) from all the houses in the town to the common disposal place If there is no sewer the drains from a building may be connected to and discharge into a septic tank, which in turn is connected to a field drainage system or to a soakage pit (see p 155)

House drains must always be constructed of heavy cast iron or of glazed stoneware pipes properly jointed so that they are airtight and watertight

Glazed stoneware is made by burning a mixture of flint and sand until it forms a dense hard and strong material. The glazed or shiny surface is obtained by throwing salt into the kiln while the pipes are burning The fumes from the salt form a kind of glass on the inside and outside of the pipes and this renders them both airtight and watertight.

[illegible]

cepting chamber, and must be not less than 12 inches and not more than 6 feet above the surface of the adjoining ground The top of this pipe must be protected with an inlet valve to prevent the escape of foul air and mosquito gauze to prevent the entrance of mosquitoes

Method of Laying—Pipe laying starts at the lowest end of the drain—that is at the end furthest away from the building—and the pipes are laid with their sockets pointing towards the higher end (*i.e* in the direction of the building), thus the flow of sewage through the pipes is from socket to spigot, as shown by arrows at (*a*) Fig 58 They must be laid in such a manner as to rest on a solid bed throughout their length. To ensure that they do not rest upon their sockets only, holes must be made in the ground or concrete under the sockets so as to leave them free These holes must be filled in after the drain has been tested

[illegible]

the top of the barrel of the pipes

Cast iron or steel pipes may be supported on 12 inch concrete piers one behind each socket and at a distance of not more than 6 feet apart measured from centre to centre of the piers

Stoneware pipes may be joined with cement mortar—i.e, 1 part cement and 2 parts sand See (*b*) in Fig 58 which shows one half of a socket and spigot joint.

If the pipes are of cast iron or other metal jointed with ordinary socket joints the joints may be caulked with molten lead or with lead wool.

In the case of stoneware pipes note that the cement mortar is sloped to an angle of 60 degrees on the outside

of the joint, forming a collar around the pipe Care must be taken to remove any mortar which may have been squeezed into the pipe otherwise this will tend to collect solid matter from the sewage and will probably cause a blockage The cement may be removed by means of a half round scraper passed down the pipe as soon as the joint is finished—that is before any cement which may have been squeezed into the pipe has time to set.

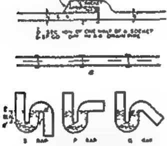


FIG 38 —DRAINAGE DETAILS

Traps.—Traps in sanitary fittings and drainage work are arrangements which are designed to retain a small [illegible]

round pipes and are used for the outlets of sanitary fittings such as baths sinks lavatory basins and so on. They are made in lead copper brass gunmetal iron, glazed stoneware and enamelled earthenware The shape

varies according to the position of the outlet, the standard shapes are shown in Fig 58, which illustrates the forms known as 'P,' Q," and "S" traps from their resemblance to these letters of the alphabet.

Sanitary Fittings.—Sanitary fittings include lavatory basins, sinks, baths, water closets and urinals The materials in general use for their manufacture are cast iron and different kinds of pottery for the actual fittings and various alloys of metals for the pipes, traps taps and other accessories

Cast iron is hard, though brittle, dense and impervious, and may be cast into any shape desired and in large sizes When used for sanitary fittings, the surface is generally covered with vitreous enamel, but it may also be painted or galvanized

Pottery used for sanitary fittings is made from various kinds of clay burnt in kilns The kind in most general use is made from fireclay a porous substance which is rendered impervious by being covered with an enamel of porcelain, but the best kind of pottery for this purpose is that known as **vitreous china**, which is impervious throughout its mass

Alloys are mixtures of two or more metals Those in most general use in sanitary work are

Brass, composed of copper and zinc

Bronze, composed of copper and tin

White metal, *composed of copper*, *nickel* and zinc or of copper, tin and antimony

General Consideration—All sanitary fittings should be simple in use and efficient in action They must be strong and durable, and should be, as far as possible self cleansing in use They should provide ready access for any necessary cleansing operations

Water Closets and Latrines.—These are very important sanitary fittings, being designed to receive and discharge excreta There are many different types but the principles of construction of all types are the same *Here we shall confine ourselves to the consideration of* two types only—viz **the pedestal washdown** closet, and the **squatting block latrine**

General Specifications—A water closet should be constructed of glazed earthenware enamelled fireclay or vitreous china It must be fitted with a flushing rim and be of such a shape capacity and construction as to contain a sufficient quantity of water and to allow

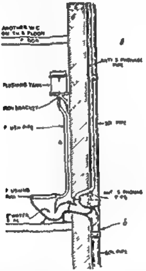


FIG 59—A WATER CLOSET

excreta to fall free of the sides directly into the water It must have an efficient trap with a water seal 2 inches in depth, and having an exposed and accessible outlet connecting it to a soil pipe or drain Fig 59 shows the section of a washdown water closet connected to a soil pipe and illustrates the above points.

Squatting Block Type Latrines—Fig 60 shows the type The basin or pan is set level with the floor and is embedded in concrete In this case the basin and

trap are separate parts joined together at the time of fixing by a socket and spigot joint. This has the advantage that the outlet may be turned to face in any required direction. In general principles this type is similar to the pedestal type, but the basin is shallower and no seat is provided.

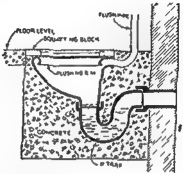


FIG 60.—A SQUATTING BLOCK LATRINE

Arrangements for flushing Both Types.—A special flushing tank, fitted with waste-preventing apparatus and of not less [illegible]
The flush p[illegible]
and made [illegible]
suitable ma[illegible]
pipe leading from a flush tank may be connected to the pan of a water closet or urinal.

Flushing tanks are made of cast iron, sheet steel, glazed earthenware, enamelled fireclay, and sometimes of glass. They may be supported on brackets as shown in Fig. 59, or may be screwed directly to plugs in the wall by means of lugs formed on the casting.

The waste-preventing apparatus varies greatly in detail in different makes, but nearly all depend upon **siphonic action** to empty the tank and a **ball valve** to check the incoming supply.

One system is shown in Fig 61 Its action is as follows

1 The dome is lifted by a pull on the chain
2 The chain is released suddenly and the water within the dome is thrown over the top of the inner tube
3 This sets up siphonic action which empties the tank quickly and gives a good flushing action in the basin of the closet.

Flushing tanks are usually fixed at least 5 feet above the pedestal or squatting block but some types are specially made to give a good flushing action when

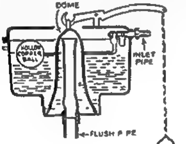


FIG 61 —A FLUSHING TANK

fixed quite close to the seat in European types of closet Water is supplied to the tank through the inlet pipe, and is controlled by an automatic ball valve The valve is opened by means of a lever, at the extreme end of which is a hollow ball made of copper which floats on the water As the level of the water sinks the ball drops with it and the valve is opened When the water rises the ball floats upwards raising the lever, which pushes the valve on to its seating this closes the valve and no more water can enter the tank (see Fig 61)

Siphonic Action.—To illustrate this bend a piece of glass tubing so that one arm is twice the length of the other Place the short arm in a vessel of water and fill the tube by suction release the tube and the water will flow from it at C, continuing to do so until the level of the water in the vessel has fallen below the mouth of the short arm of the tube This flow of water through the tube is called siphonic action the tube being the siphon The action is due to the pressure of the atmosphere on the surface of the water (A) As long as water is passing through the siphon or tube the pressure of the atmosphere inside at B is less than that outside at A, and water is forced through the tube until air again enters and the pressure inside at B becomes equal to that outside at A To start a siphon then it is necessary to draw water through the tube when it will continue to flow until the supply has been exhausted

FIG 62—A SIPHON

In the case of the flushing tank (Fig 61) the dome forms the short arm of the siphon and the flush pipe is the long arm As the water rises in the tank it also rises in the dome when it is thrown into the inner tube by the raising and sudden release of the dome siphonic action is started by means of which the tank is emptied through the flush pipe

Siphonage in Traps—When sanitary fittings are placed one above the other and discharge into the same waste or soil pipes (e g in large buildings of the hotel type), there is danger that the discharge from a fitting above may siphon out the contents of the traps of the ones below and leave nothing to prevent the foul air from the drain entering the building Refer to Fig 59 and assume that there is a water closet on the floor above and discharging into the soil pipe When the discharge from above reaches the point (*b*) a partial vacuum is caused in the branch pipe and the air pressure at the bend (*c*) is less than that on the surface of the

water in the pan Siphonic action is started and the water which forms the seal of the trap is forced out

To prevent this happening, an antisiphonage pipe—that is, an air pipe—is run alongside the soil pipe [illegible]

a point not less than 3 inches and not more than [illegible] inches from the highest part of the trap, the connection must be oblique and in the direction of the flow (see Fig 59)

Antisiphonage pipes for soil pipes must not be less than 2 inches in diameter, and must be of the same quality and jointed in the same manner as the soil pipe itself When fitted to a waste pipe antisiphonage pipes must be of the same size and quality as the waste pipe.

Antivacuum Traps.—These are traps specially made to prevent siphonage, and are sometimes fitted to waste-water fittings instead of an antisiphonage pipe being provided

Drain Testing.

The two methods of doing this which are in most general use are known as the water test and the smoke test. The first of these the water test [illegible] the one which is usually employed for testing new drains before they are covered over Drains must be watertight, and local regulations ask that they shall be capable of resisting [illegible]

drain leaves the building

The water level [illegible] marked and is watched for a period of half [illegible] one hour any subsidence denotes [illegible] leakage If the drainage system is a large one the test

may be applied section by section between the inspection chambers beginning at the highest end of the drain

The smoke test is used for detecting and locating leakages in existing drains especially in old ones which are likely to be damaged by the application of the water test It is also used for testing vertical pipes such as soil pipes The smoke test is applied by the use of a **smoke machine** with bellows which are used to force the smoke into the drains under a slight pressure The smoke is produced by the burning of special paper or oily cotton waste in the machine and is conveyed to the drain through a flexible rubber tube connected to one of the drain plugs

All openings in the section of drain under test are plugged with drain plugs and the smoke is introduced at the lower end Leakages are shown by the fall of the dome which is attached to the machine and may be located by the escape of smoke from any of the joints or from any cracks or holes in the pipes themselves

The Air Pressure Test.—This is a good test for soil and waste pipes but it is not so suitable for underground drains although it may be applied to them if desired The method of application is shown in Fig 63

The pipe to be tested is plugged at both ends with drain plugs which should be water sealed as shown in order that any leakage of air or water through or around them may be detected A rubber tube (*b*) is connected to a metal tube which is inserted through the topmost drain plug (*a*) To the lower end of this rubber tube is attached a bellows (*d*) and a branch tube to which is fixed a glass U tube ½ inch diameter (*c*) Water is poured into the U tube and as it is not under pressure it reaches the same height in both arms Air is now forced into the pipes by the bellows the pressure thus produced raises the level of the water in the outer arm of the U tube

This process should be continued until there is a difference of 5 inches between the water levels in the two arms of the tube If this difference remains constant

for at least five minutes, the pipe may be considered to have passed the test, but if it is not maintained a leakage of air is indicated. This may be located by smearing suspected joints with a soap solution, when any escape of air will be shown by the appearance of soap bubbles.

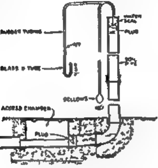


FIG. 63.—AN AIR PRESSURE TEST

Ultimate Disposal of Sewage under the Water Carriage System.

In large towns this is undertaken by the township authority, which provides sewers and disposes of the sewage. Where no sewers exist, each householder makes his own arrangements for disposal, subject to the approval of the authority. In such cases the septic tank system may be adopted.

A **septic tank** is usually made of concrete or of brick work set in cement mortar and plastered in cement on the inside to render it watertight. Its purpose is to receive the sewage from a building and to retain it until the solids contained in it have liquified and can be passed on to a system of subsoil drains or to a soakage pit. This liquefaction or digestion of the fæces is brought about by the action of certain bacteria and

to give these time to act a septic tank should be de signed to hold three days flow of sewage When the tank is first used some time elapses before proper work ing conditions are set up and the tank should never be completely emptied after septic action has started although it may be necessary to remove some of the sludge from time to time Disinfectants must not be used in water closets which discharge into septic tanks otherwise the action of the bacteria may be retarded and the septic tanks may cease to function properly

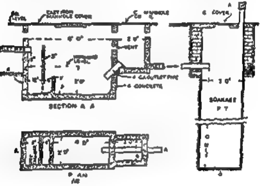


Fig 64 —A Septic Tank

Fig 64 (a) shows a septic tank suitable for the d s posal of water-closet waste only from a house occup ed by eight persons Th s has been designed on the assump tion that the discharge will be 6 gallons for each person per day and allowing for three days sewage rest in the septic tank

Soakage Pit.—At (b) is shown the soakage pit properly covered with concrete and fitted with an airtight man hole cover similar to those used for inspection chambers in the drainage system (see Fig 63) This pit should be at least 25 feet away from any building and in such a *position that there is no risk of the liquid which*

percolates from it into the soil gaining access to a spring or well which is used for drinking water Great care must be taken to avoid this, as water which has been contaminated by the effluent from a soakage pit may give rise to outbreaks of typhoid or of other water-borne diseases In no case should it be within 150 feet of any source of water supply used for human consumption In some cases the septic tank is omitted and the sewage is discharged directly into the soakage pit

Irrigation System Under this system the effluent from the septic tank is passed into a series of subsoil drains, which may be constructed of field drainage pipes in a manner similar to that already described as suitable for the subsoil drainage of damp sites In order that purification of the effluent may be helped by the action of oxygen in the air and of bacteria in the soil the drains for this purpose should not be laid more than from 12 to 18 inches below the surface of the ground If the soil is porous about 1 foot of pipe should be allowed for each gallon of daily discharge from the tank, if it is not, a greater length should be given If [illegible] ever, be taken that the pipes are laid in such a position that the effluent does not contaminate any supply of drinking water

Exercises

1 What is the difference between a sewer and a drain? Of what practical use is a knowledge of the distinction between them?

2. Of what materials must the pipes for house drains be made? Describe how a drain is laid and jointed Illustrate by sketches

3 Draw to scale a plan and section showing an inspection chamber and intercepting trap, taking the depth to the invert as 4 feet Describe the uses of both chamber and trap

to give these time to act a septic tank should be designed to hold three days' flow of sewage When the tank is first used, some time elapses before proper working conditions are set up, and the tank should never be completely emptied after septic action has started, although it may be necessary to remove some of the sludge from time to time Disinfectants must not be used in water closets which discharge into septic tanks, otherwise the action of the bacteria may be retarded and the septic tanks may cease to function properly

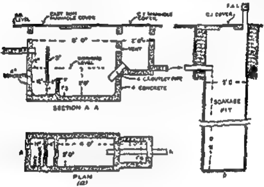


FIG 64 —A SEPTIC TANK

Fig 64 (*a*) shows a septic tank suitable for the disposal of water-closet waste only from a house occupied by eight persons This has been designed on the assumption that *the discharge will be 6 gallons for each person* per day, and allowing for three days' sewage rest in the septic tank.

Soakage Pit.—At (*b*) is shown the soakage pit, properly covered with concrete and fitted with an airtight manhole cover similar to those used for inspection chambers in the drainage system (see Fig 63) This pit should be at least 25 feet away from any building, and in such a *position that there is no risk* of the liquid which

give rise to outbreaks of typhoid or of other water borne diseases In no case should it be within 150 feet of any source of water supply used for human consumption In some cases the septic tank is omitted and the sewage is discharged directly into the soakage pit

Irrigation System.--Under this system the effluent

purification of the effluent may be helped by the action of oxygen in the air and of bacteria in the soil the drains for this purpose should not be laid more than from 12 to 18 inches below the surface of the ground If the soil is porous, about 1 foot of pipe should be allowed for each gallon of daily discharge from the tank, if it is not, a greater length should be given If a sufficient amount of land can can be set aside for the purpose this is a better method of disposing of the effluent than the use of a soakage pit because a considerable amount of purification takes place before the liquid sinks deeply into the ground Care must, however, be taken that the pipes are laid in such a position that the effluent does not contaminate any supply of drinking water

Exercises.

1 What is the difference between a sewer and a drain? Of what practical use is a knowledge of the distinction between them?
2. Of what materials must the pipes for house drains be made? Describe how a drain is laid and jointed Illustrate by sketches
3 Draw to scale a plan and section showing an inspection chamber and intercepting trap, taking the depth to the invert as 4 feet Describe the uses of both chamber and trap

must keep his hands dry, and on no account must he moisten them with spittle or by dipping them into the milk, he should wear a clean white overall and a white washable cap

The first two squirts of milk from each teat should be rejected, because the mouths of the teats frequently contain dirt, or bacteria and this first milk may be infected

Immediately after milking the milk must be removed from the shed and placed in a covered receptacle It should be cooled as soon as possible to a temperature of less than 50° F, in order to retard the multiplication of bacteria, which increase very rapidly in milk at body heat.

This, however, is generally impossible unless a refrigerator is available, and we usually have to be satisfied if the milk is cooled to a temperature of not more than 5°F higher than that of the water available for use in the cooler

A milk cooler is usually a box like apparatus with corrugated outer surfaces over which the milk runs in a fine stream It is kept cool by a flow of cold water through pipes which are arranged inside the apparatus

Immediately after cooling the milk should be poured into sterile glass milk bottles which should then be covered with discs and kept in a cold store at a temperature below 50°F until delivery

The milk bottles should have a wide mouth, so that they may be cleaned easily and they should be sealed with properly fitting waxed cardboard discs specially made for the purpose Ordinary bottles of the type which is used to contain whiskey spirits, etc, are not good, as the narrow neck makes proper cleansing almost impossible

(c) The Dairy Utensils—These include the milking

1 They must keep their persons and clothing in a clean condition

2 If they are suffering from or have been in contact with infectious disease they must report to a Medical Officer of Health and must not resume work until they have received his permission to do so

(*b*) **The cows** must be healthy and should be kept clean and well groomed If possible they should be examined by a veterinary surgeon once in every three months and any animal showing signs of disease likely to affect the milk injuriously should be removed from the herd The milking herd should be kept apart from other cattle

Fig 65 —Floor of a Milking Shed

(*c*) **The milking shed** should be provided with a floor *of cement concrete so finished that the surface is slightly* rough The part on which the cows stand should be 7 feet wide and should have a fall of 2 inches to a manure channel which should be at least 4 inches deep at its highest end and 18 inches wide (see Fig 65)

The roof should be of corrugated iron or other dustless material The sides may be open or partly enclosed if desired

The milking shed must be kept clean and nothing should be done to cause dust in it within half an hour of milking

(*d*) **Procedure** —Immediately **before milking** the udder and teat of each cow must be washed with clean water and dried with a clean cloth The milker must wash his hands with **soap and water** and dry them on a clean cloth his milking stool should be scrubbed clean so that he will not dirty his hands when moving it. He

during the course of delivery, or after reaching the premises of the consumer

8 **Cholera.**—The milk may be contaminated by flies (see 7) or by infected water (see 4)

Definition of a "Carrier"—It is possible for certain people to carry the germs of an infectious disease and [illegible] infect other people without themselves developing the symptoms of the disease Such people are known as "carriers," and the fact that they are harbouring harm [illegible]

it is impossible to ensure these conditions at present especially [illegible] the tropics, but there are several methods by which milk may be made safe for human consumption There are four of these in general use—viz. boiling, complete sterilization pasteurization and drying

1 **Boiling.**—This is a method which can be adopted in every home As soon as the milk is delivered, [illegible] should be raised to boiling point and then allowed to cool. It should be kept in a clean vessel in the coolest available place, and should be protected from contamination by dust or flies or from any other source

By this method the pathogenic organisms (but not spores) will be killed and the milk will be less likely to go sour, as the organisms which produce lactic acid will be reduced in number

2 **Complete Sterilization.**—This means the killing of all micro-organisms and their spores and can only be done by keeping the milk at a temperature above normal boiling point for at least twenty minutes When the process is complete, the milk should be stored as described above

The disadvantages of both these methods (especially of No 2) are that they alter the character of the milk and affect its nourishing qualities also that the vitamins are destroyed.

In spite of this the danger of infection from raw milk [illegible] so great that the disadvantages of boiling are out

All utensils should be
- (a) Rinsed with cold water immediately after use then
- (b) Washed and scrubbed with hot water and soda then
- (c) Rinsed with clean water then
- (d) Sterilized by steam or boiling water

After sterilization the utensils must be stored in a clean dust proof place until required for use

Infected milk.—The diseases which may be communicated to man by infected milk include tuberculosis undulant fever epidemic sore throat typhoid dysentery diphtheria epidemic diarrhœa and cholera

How the Milk may become Infected—1 Tuberculosis.—The bovine tubercle bacilli may be contained in the milk yielded by a diseased cow or the milk may be contaminated by the fæces or other discharges from diseased animals

2 **Undulant Fever**—A cow which has suffered from contagious abortion may become a carrier and although at the time herself perfectly healthy may pass the organisms of the disease in her milk These organisms set up undulant fever in man

3 **Epidemic Sore Throat.**—The milk may become infected with bacilli from the udder of a cow which is suffering from mastitis or from ulcers or eruptions on the teats

4 **Typhoid**—Milk may be infected by carriers of typhoid or by contacts employed in the dairy It may also be infected by the use of contaminated water for the purpose of washing the dairy utensils or for the purpose of fraudulent dilution of the milk

5 **Dysentery**—See Typhoid

6 **Diphtheria.**—The milk may be infected by carriers engaged in work in or around the dairy

7 **Epidemic Diarrhœa**—The milk is contaminated by dust or flies this is evidence of careless handling or improper storage (probably both) while at the dairy

during the course of delivery, or after reaching the premises of the consumer

8 **Cholera.**—The milk may be contaminated by flies (see 7) or by infected water (see 4)

Definition of a "Carrier."—It is possible for certain people to carry the germs of an infectious disease and to infect other people without themselves developing the symptoms of the disease Such people are known as "carriers," and the fact that they are harbouring harmful germs can be established by medical examination

Method of making Milk safe for Food.—If milk is produced under hygienic conditions from healthy cows it is a safe and wholesome article of food Unfortunately it is impossible to ensure these conditions at present especially in the tropics, but there are several methods by which milk may be made safe for human consumption There [illegible]

[illegible]

should be kept in a clean vessel in the coolest available place, and should be protected from contamination by dust or flies or from any other source

By this method the pathogenic organisms (but not spores) will be killed and the milk will be less likely to go sour, as the organisms which produce lactic acid will be reduced in number

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The **disadvantages** of both these methods (especially of No 2) are that they alter the character of the milk and affect its nourishing qualities also that the vitamins are destroyed.

In spite of this, the danger of infection from raw milk is so great that the disadvantages of boiling are out

weighed by the protection secured against disease Method No 1 above should always be adopted when other means of safeguarding are not available

3 **Pasteurization**—This is the best method of making [illegible]

pathogenic organisms which may be present, and to reduce the number of lactic acid producing organisms *without any change in the nature of the milk and without* destroying the vitamins To accomplish this the milk is **held at a temperature of not less than 145° F. and not more than 150° F. for at least thirty minutes, and is then immediately cooled to a temperature of not more than 55° F.** These limits of temperature must be absolutely observed if the process is to be successful, if the temperature falls below 145° F the bacteria will not be killed, and, on the other hand, if it rises above 150° F the physical and chemical character of the milk will be changed

4 **Drying.**—By this method all water is removed from the milk by evaporation, the solids remaining in the form of a dry powder which can be made into liquid milk again by the addition of the proper amount of water The powder is not quite sterile, but, owing to its dry state, micro-organisms cannot develop and increase The powder is called "milk powder" or "dried milk", the milk made from it is nearer in character and vitamin content to fresh milk than is boiled or sterilized milk This is due to the fact that only a very short exposure to heat is needed to turn the milk into powder

The process calls for special equipment and cannot be carried out in the home There are several methods in use, including

(1) **Roller Drying**—Very thin films of milk are passed over the surface of revolving rollers heated to a high temperature by steam or hot air passing through them The heat causes the water in the milk to evaporate

and the solids remain in the form of thin wafers or flakes which are afterwards powdered.

(2) **Spray Drying.**—A fine spray of milk is passed through a current of hot air during the process the water evaporates and the solids fall in the form of a powder

Milk powder is packed in sealed airtight tins and will keep for a long period if the tin is left unopened

Milk Products.

1 **Cream.**—This may be taken from the milk by "skimming" or by "separating"

Skimming—Milk is allowed to stand in a large bowl until the cream rises to the surface when it may be removed A large spoon perforated with small holes is the best to use for this purpose as it allows the milk to pass through and retains the cream The remaining milk is called skimmed milk and is of course inferior in quality to whole milk The number of bacteria in this cream is usually very high as they rise with the cream

Separating—In a large dairy cream is usually removed by a machine called a "separator" The milk is put into a cylinder which is then rotated very rapidly The heavier part of the milk is thrown to the outer part of the machine and the cream which is lighter is left in [illegible] e cream the [illegible] lk and con [illegible]

Cream may be pasteurized in the same way as milk no chemical substances should be added to preserve it

2 **Butter** is milk fat clotted together It is prepared by churning separated cream It contains [illegible] to 85 per cent milk fat, small quantities of proteins salts and sugar and should have not more than 16 per cent. water

The cream is allowed to stand for some hours in order to give the bacilli which produce lactic acid time to work The acid produced by them during this period causes the milk to "sour" or "ripen" as it is called This is necessary in order to give the butter a good

flavour and so that the globules of fat may break down easily when churned

Churning is simply a means of shaking the cream violently so that the globules of fat are broken up and clotted together into a mass, or lump, of fat, which is called butter

The butter is washed with cold water and then beaten to remove all surplus moisture and to make it firm, some common salt is usually added It is then packed into casks or made up into any shape and size required for use

Butter is sometimes adulterated by the addition of other kinds of fat or of water No preservative other than salt is allowed by law Pasteurized cream should be used in order to ensure that the butter shall be free from tubercle bacilli, but the flavour of butter made from such cream is not generally liked so the cream for butter making is usually in the raw state

3 Margarine is an imitation butter made from animal or vegetable fats mixed with milk in order to give a taste resembling that of butter When good, it is an excellent food

4 Cheese.—When milk is soured, the proteins or caseins of the milk form clots (called "curds"), which are contained in a clear liquid known as whey These clots or milk curds, after having been removed from the whey and pressed into solid form, and having undergone various other processes, are known as cheese

Cheese, therefore, is the clotted casein of milk, together with varying proportions of milk fat and salts It is made from separated milk, whole milk, or milk with extra cream added according to the proportion of fat required in the finished product Genuine cheese must contain no fat other than that obtained from milk

5 Ghee is clarified butter—that is, butter which has been heated and allowed to cool, this process helps to improve its keeping qualities, but so alters its flavour that it is not liked by most Europeans It is however, if well made and in good condition, an excellent food and is in very general use among the Indians

Preparation of Ghee.—Butter is melted over a slow fire and then set aside to cool After cooling the whiter and more fluid portion is removed, this is the best quality ghee The thick residue is then mixed with ground nut oil and used as inferior ghee

Ghee may also be prepared by boiling butter over a clear fire until all the water has evaporated It should be *skimmed from time to time during the process* It is then strained through a cloth

Condensed milk is milk from which most of the water has been removed, by this means its bulk is greatly reduced and storage and transport are greatly facilitated. It is sold in airtight tins and is very useful in places where it is difficult to obtain fresh milk, when required for use, the correct amount of water should be added

Sweetened condensed milk is made by mixing milk with sugar and then reducing the water by evaporation in a vacuum pan until the mixture is of the desired consistency This is then poured into tins or casks and sealed.

This milk will remain sound for a long time even after the containers have been opened, as the amount of added sugar is sufficient to retard the growth of bacteria

Evaporated or Unsweetened Condensed Milk.—This is made in a similar manner to the above but no sugar is added. After the condensed milk has been put into the tins, these are immediately sealed and sterilized by *heating in a steam oven* As long as the tin is air tight the milk remains good, but once the tin has been opened it will keep for about the same length of time as would ordinary boiled milk

Condensed skim milk is milk from which the cream has been removed before condensation either with or without sugar, has taken place It should not be used as a food for infants

The advantages of condensed milk are It is usually free from living disease germs. It can be kept for a very long time in good condition and ready for use

and is therefore very valuable in places where good fresh milk is not easily got It is easily packed and can be sent very long distances without deteriorating

The disadvantages are that it is usually more expensive than fresh milk, and that some of the vitamins may have been destroyed during the process of condensation This is not of great importance if these are present in other foodstuffs consumed

II —PRESERVATION AND STORAGE OF MEAT AND OTHER FOODS

Necessity for Preservation—Most food is at its best when fresh The best meat is usually fresh meat the best eggs are newly laid, the best fruit and vegetables are those straight from the garden It is not, however, always possible to obtain food supplies in this ideally fresh condition for many reasons certain articles of food may not be obtainable locally, and must be imported from some other district or country, some foods (fruits for example) can only be produced at certain seasons of the year but at these seasons the supply greatly exceeds the demand and unless some method of preserving or storing the surplus is evolved great wastage of food stuffs is caused There may be a bad year of drought in which case any foods which have been preserved or stored and carried over from the previous year become very valuable indeed For these and many other reasons *much time and thought have been given to discovering* the best methods of preserving and storing foods, so that they may remain in as fresh a condition as is possible over long periods of time

Why Food becomes Unsound—If a piece of meat or vegetable is left uncooked for a few days it grows soft

food into its elements and is caused by the action of bacteria which have gained access to the food If the atmosphere is warm and moist decomposition proceeds more rapidly if it is dry and cold, decomposition is

checked In other words the bacteria which cause decomposition flourish and multiply rapidly in a hot moist atmosphere, but are unable to grow in a very cold or dry one.

If we can prevent the access of these bacteria [redacted] food stuffs or can create conditions which are unfavourable [redacted] their development we can prevent decomposition and the food will remain in sound condition for a long time

How Food is Preserved—This is accomplished [redacted] the following ways

(a) Methods which create conditions unfavourable for the development [redacted] bacteria:

Method	*Kind of Foodstuffs for which the Method is usually Employed*
1 Salting	Meat fish
2 Pickling with brine	Meat fish
3 Drying	Meat, fish fruit, vegetables cereals milk egg yolks
4 Smoking	Meat fish
5 Refrigeration (preservation by cold)	Meat, fish fruit, vegetables eggs milk
[redacted] Preserving with sugar	Fruit.
7 Preserving with chemicals	Sausages fruit jam certain wines and other drinks

(b) Destruction of bacteria and protection of the food from the entry of further bacteria:

Method	*Kind of Foodstuffs for which the Method is usually Employed*
1 Sterilizing and canning	Meat, fish vegetables fruit
2. Sterilizing and bottling	Vegetables, fruit.

(c) Covering with Some Substance to prevent Access of Bacteria.—Eggs preserved [redacted] water glass, etc

Methods which create Conditions unfavourable for the Development of Bacteria.

1 Salting—Salt checks the action and multiplication of micro-organisms and especially of the kinds that cause decomposition it does not however destroy disease producing organisms All meat therefore which is intended for salting must be free from disease and perfectly fresh and sound before being treated.

Method—A dry mixture of common salt sugar and saltpetre is rubbed well into each piece of meat A clean store preferably lined with materials having a smooth impervious surface is prepared On the bottom is put a heavy layer of salt and on this a layer of meat prepared as described above Next comes a heavy layer of salt then a layer of prepared meat and so on in rotation until the store is full.

The meat is left undisturbed for a period of from ten to twelve days when the salting process will be complete it is then washed and is hung up to dry in a drying room It is sometimes hung in a smoke chamber for a few days the temperature being maintained at 85° F (see Smoking)

2 Pickling.—This is another method of using salt, but in this case the meat is put into a strong solution of salt and water called brine Again only meat which is free from disease and which is perfectly fresh and *sound should be used*

Method—The pickle or brine is first prepared it consists of salt saltpetre and a little sugar dissolved in water and is very strong the strength of the solution being usually about 85 per cent This pickle is usually contained in wooden tubs which are provided with perforated wooden covers these being small enough to fall inside the tubs where they float on the surface of the brine

The meat must be perfectly sound and must have lost all animal heat before being put into the pickle When a sufficient quantity of meat has been placed in a tub the perforated cover is put on top of the meat and is weighted this ensures that all the meat will be

pressed below the surface of the brine The salt penetrates into the meat slowly and sometimes in order to hasten the process the pickle is injected into the substance of the meat by means of a pump fitted with a hollow needle like a large hypodermic syringe By this means the preservative is quickly brought into contact with the interior as well as with the surface of the meat.

The time required to complete the process of pickling depends upon the strength of the pickle the total weight of the meat, the weight of the individual pieces, and on whether or not the pump has been used About one day for each pound of meat in the tub may be taken as a rough estimate

Inspection of Pickled and Salted Meat.—If the process has not been carried out properly the meat will be pale in colour and will feel slimy if on the other hand it smells badly and is of a greenish colour putrefaction has set in. This indicates that the meat was not sound when pickled Putrefaction often starts near the bone and it is advisable when inspecting to thrust a piece of wire or a knife into the meat This should then be withdrawn and smelt if there is any odour of putrefaction the meat should not be sold for human consumption

If salted meat is hard and shrivelled in appearance it is probably old stock

3 **Drying.**—This method of preserving foodstuffs makes use of the fact that bacteria cannot develop or flourish in a perfectly dry medium The manner in which the drying is done varies according to the kind of food which is to be preserved but in each case the process depends upon the evaporation of all moisture by dry heat and storage afterwards in a dry atmosphere or in airtight tins.

4 **Smoking.**—This is a process which is sometimes applied to fish or meat after salting or drying The meat or fish is hung from iron bars in a chamber which is provided with a ventilator in the roof smouldering wood or sawdust fires are lighted to generate smoke which is drawn upwards to the ventilator and thus per-

meates the air of the whole chamber The temperature inside the chamber must not exceed 85° F

Inspection of Dried Foods—An unpleasant odour indicates decomposition If the food has been exposed to damp, moulds may have formed, their presence being made evident by green or black patches on the surface

5 **Refrigeration**—This is the storage and preservation of food in a cold atmosphere When the temperature of foodstuffs is brought very low, the action and devel opment of the organisms which cause putrefaction is arrested and the food can be kept in sound condition for a very long time Cold does not kill the organisms

The cold store or refrigerator [redacted] maintained at the temperature desired in the way already described in the paragraph dealing with the manufacture of ice (Chap ter II) This temperature varies according to the kind of food which is to be preserved Those which have been found by experience [redacted] give the best results are given below together with the kind of food to which they apply

Kind of Food		*Temperature of Cold Store*
Meat Fish Poultry, etc	When intended to be kept for a few days only, as in a butcher's shop or private house	36° to 45° F
Meat	chilled for export purposes	29° F
Meat	frozen for export purposes	15° to 16° F
Milk		45° to 50° [redacted]
Eggs		33° F
Fruit (Note—The different kinds of fruit vary very much in the amount of cold they are able to withstand without injury The temperature suitable for each kind has to be found by experi ment)		As cold as pos sible without damaging the fruit

6 **Preserving with Sugar**—Sugar retards the growth of bacteria in food in very much the same way as does salt as we have seen a little sugar is added [redacted] the mixture used for salting and pickling meat. Sugar however is mainly used as a preservative for fruits in the form of jams jellies and crystallized fruit

Crystallized fruit is fruit which has been boiled in a syrup made from sugar and water and which has then been allowed to dry As a result of this process the sugar forms crystals in the substance and on the surface of the fruit.

Jams and Jellies.—For jam the fruit is boiled with its own weight of sugar until it "sets" or becomes stiff on cooling it is then poured into jars or tins and sealed

Jelly is prepared in the same way except that the solid parts of the fruit (i e seeds skins etc) are removed by passing the jam through a strainer before pouring it into the jars or tins.

7 **Preservation of Food by Means of Chemical Antiseptics.**—This is not considered to be a good method of preserving food and should only be used when no other means can be employed

In England only two chemical substances may be added to food they are benzoic acid and sulphur dioxide and they may only be used in certain cases and in specified small amounts If either of these two preservatives has been used in food which is offered for sale the fact must be declared on a label fixed to the food container

The foods [redacted] which one or the other of these chemicals may be added are

1 Sausages and sausage meat
2 Certain kinds of fruit
3 Jams jellies and crystallized fruit
4 Sugar
5 Cornflour
6 Gelatine
7 Certain wines and other drinks

2 Examine the can for damage, rust and soldering defects, remembering that if the can is not absolutely airtight the contents will most probably be unsound.

If the cans are very rusty, some of them may have rusted through, these will be no longer airtight. All leaking and non-airtight tins should be condemned

3 The ends of the cans should be depressed, or concave Any bulging or convexity may indicate that the contents have decomposed, and that the gas thus generated has pressed out the ends of the cans Such cans are known as blown cans

In the case of acid fruits, the acid of the fruit sometimes attacks the metal of the can, in which case hydrogen gas is generated, this presses out the ends of the can, which then appears to be blown

All blown cans should be condemned.

4 Tap the surface of the can with the knuckles or with a piece of wood, a good can should emit a dull note, whilst a bad one, which contains gas or air, gives a sound like that of a drum This method is known as testing by **percussion.**

Summary showing methods of preserving various foods

Food	*Methods adopted for Preservation*
Meat	Salting, pickling, canning, freezing, chillin, drying
Fish	Salting, pickling, canning, freezing, chilling, drying
Milk	Sterilizing, condensing; evaporating, drying, refrigeration
Vegetables	Canning, bottling, drying, refrigeration
Fruit	Canning, bottling, drying; crystallizing, making into jams and jellies, refrigeration
Eggs	Refrigerating at 33° F, preserving in water glass, etc

Storage of Foodstuffs.

During storage and at all other times every effort should [redacted] made to prevent contamination of food by exposure to dust flies and other vermin or by unclean and unnecessary handling

In the House.—Every house should have a food safe—i.e., a cupboard with sides and door made of wire gauze which will admit air and keep out flies and other insects This should stand in a cool clean well ventilated part of the house—*e g., on a verandah—never in a living or sleeping room*

In this safe should be kept all meat and milk whether cooked or not and all cooked food which is required for further use The safe and its contents should be protected from dust.

In Shops—In the Butcher's Shop.—Meat which [redacted] awaiting sale should be kept in a large fly proof meat safe This may be easily and cheaply constructed in one corner of the shop the materials required being a wooden framework and wire gauze The floor of the shop should be of cement concrete which should be kept clean by washing with water not by dry sweeping Customers should not be allowed to handle the meat before purchase

In other food shops—e g cooked food shops sweet shops eating houses confectioners shops bakers shops and grocers shops—food which [redacted] to be exposed for sale (such as cooked meats cooked fruits bread sweet meats, ghee butter) should be covered with or wrapped in fly proof material or should be placed in closed boxes with glass lids or fronts which will exhibit the food and yet prevent contamination by dust and flies These boxes can be cheaply made from empty petrol boxes etc

All foodstuffs which are intended to be eaten without further cooking must be adequately protected from contamination by flies or other vermin when offered for sale *This is usually a legal requirement*

The main stock of cereals in all shops should be stored in rat proof bins or grain cribs

ted, then the spleen and kidneys, the prescapular and inguinal lymphatic glands, udder, bones and joints

Appearance of tubercles in secondary infections—i e, those produced after generalization has set in

1 The tubercles are very numerous, and are scattered throughout the substance of the infected organ

2 Being of the same age, they do not vary much in size or in the stage of their development, their size is about that of a millet seed

Inspection of Carcass after Evidence of the Presence of Tuberculosis has been Detected.—If the inspection described in Section IV of this chapter gives grounds for suspecting that a carcass is infected by tuberculosis, the following routine should be observed

1 Examine the surfaces and substance of all organs and their lymphatic glands for tubercles, this should be done both by touch and incision

2 Examine by cutting into slices the following lymphatic glands in the carcass itself lower cervicle, presternal, suprasternal, prescapular, *supramammary (in female), superficial inguinal* (in male) iliac and sublumbar The precrural and popliteal may also be examined if necessary (See Section IV for situation of lymphatic glands)

Action to be taken when evidence of tuberculosis *has been found*

Organs.—If tuberculosis is found on the surface or in the substance or in any of the associated lymphatic glands, the organ should be seized

Head.—If any of the lymphatic glands of the head are affected, the head and tongue should be seized

Carcass.—The entire carcass should be seized when either of the following conditions are found

(a) Tuberculosis with emaciation.

(b) Generalized tuberculosis

The following are regarded as being evidence of generalized tuberculosis

1 Miliary tuberculosis of both lungs—i.e. when there are numerous minute tubercles about the size of millet seed scattered throughout the substances of both lungs

2 When the lesions are multiple acute and actively progressive *Note.*—Lesions are acute and actively progressive when they are still infective—i.e., when they show no signs of degeneration such as calcification or encapsulation

3 When there is multiple and widespread infection of the lymph glands of the carcass

4 When there are diffuse acute lesions on both the pleura and the peritoneum and at the same time any of the lymph glands of the carcass are enlarged or contain visible tubercular lesions

5 When in addition to tuberculous lesions in the respiratory or digestive tracts, there are lesions present in any of the following spleen kidney udder testicle brain and spinal cord or their membranes

6. Congenital tuberculosis in calves—i.e. tuberculosis which is present at birth

Localized Tuberculosis.—All other cases of tuberculosis should be regarded as localized and only the parts containing the lesions and those adjoining the lesions should be condemned.

II **Anthrax**, or splenic fever is caused by a bacillus called *Bacillus anthracis* The disease is set up when either the bacillus or its spores gain access to the blood of the animal which they may do through infected food or water Of the food animals cattle and sheep are most often affected young cattle are especially liable to con

5 The walls etc must then be given two coats of limewash.

III **Rinderpest or Cattle Plague**—This is an infectious disease which m most often found in cattle and of which the causative organism has *not yet been found*

Post-mortem Signs.—Inflamed patches are found on the lips and in the throat The stomach and intestines are also inflamed and swollen and red streaks may be seen in the rectum In the later stages the flesh is very dark in colour and the liver [redacted] enlarged and is dull [redacted] appearance

Action—The carcass and organs must be destroyed and the case reported to the medical officer and the veterinary officer

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IV ***Black quarter*** is caused *by a bacillus* It [redacted] most often seen in young cattle but may also attack sheep and goats Black quarter is not communicable to man

Post mortem Signs—Swellings are found on the leg loin shoulder buttocks and neck If these swellings *are cut a gas escapes and the tissues are found to be* full of serum The muscles of the diseased parts are dark red in colour and give off an unpleasant odour which increases if a portion is warmed

Action—The carcass and organs should be condemned.

V **Foot and Mouth Disease**—This [redacted] a disease caused by a virus Nearly all animals as well as man may be affected

Signs—Bladders or blisters (called vesicles) about the size of a *ten-cent* piece and *filled* with a watery *fluid* appear in the mouth on the tips and sides of the tongue on the lips at the point where the hoof joins the foot and in the cleft of the hoof They are also sometimes found on the udder and teats The vesicles burst and leave *sores the fluid which escapes contains the virus*, and is the means of contaminating pastures and other places, thus spreading the infection far and wide Animals suffering from this disease must not be moved [redacted] uninfected areas

Action.—The carcass should be detained and the case reported to the medical officer or veterinary officer: further action will depend on the advice given.

VI Parasitic Infections.—A parasite is a plant or animal which cannot lead an independent existence but which attaches itself to and derives its nourishment from another plant or animal called the "host"

Animal Parasites—There are many different kinds of these, each having its own way of living some live on the outside of the host and suck blood—e g fleas lice Others make their way into the intestines and either absorb some of the food which the host has digested—e g tapeworms and roundworms—or attach themselves to the intestines or other internal organs and suck blood—e g hookworms

In this section we shall confine ourselves to the consideration of those parasitic infections of animals which are transmissible to man by the eating of infected meat or which cause deterioration of the organs and carcass of the host thus making them unfit for human food Among the former are *Cysticercus bovis* and *Cysticercus cellulosa* of the latter those most commonly seen are flukes and hydatid cysts.

Parasites transmissible to Man through Infected Meat.

I Cysticercus bovis.—This is the cystic or bladder worm stage of a tapeworm, *Tænia saginata* which lives in the human intestine

Tapeworms may be known by their length (e g *Tænia saginata* reaches a length of 15 to 20 feet) and by their flat segmented bodies They have no digestive system, but obtain their food entirely by absorption through the skin this food consists of "chyle" or digested food absorbed from the small intestine of the host The head or *scolex* contains no brain or mouth, and appears to serve simply as a means of attachment.

The Life History of Tænia saginata.—This consists of two stages, the larval and the adult During the larval

stage the host of the parasite is the ox. The larva is known as *Cysticercus bovis*. During the second or adult stage the host is man. The cycle is as follows:

(1) A person infected with *Tænia saginata* defecates in the grass, some of the segments of the tapeworm, containing eggs, being discharged with the fæces.

(2) The membranes of the segments decompose and the eggs, being freed, stick to the grass.

(3) An ox comes along and eats the infected grass.

(4) In the stomach or intestines of the ox the eggs hatch out into larvæ. These make their way into the muscular tissues of the animal, favourite positions being the muscles of the cheek, tongue, brisket, diaphragm, shoulder and heart.

(5) Having found a suitable spot, the larvæ encyst themselves—i.e., they cover themselves with a thin skin or membrane. This is a resting phase, and the larvæ undergo no further development unless they find their way into the body of a man. The cyst is now a small semi-transparent bladder, containing fluid and the head and neck of the future tapeworm.

(6) If the ox is now slaughtered for human food and if its flesh is eaten in a raw or undercooked state the immature tapeworm will be set free during the digestive processes, and will attach itself by means of suckers on its head to the small intestine of its host.

(7) The body segments, each of which has a complete reproductive system, begin to develop from the head in the form of a chain, those furthest away from the head being the oldest, increase in size as the eggs which they contain ripen.

(8) The ripe segments become detached and are discharged with the fæces.

The cycle is now complete, the infection having been carried from man to the ox and from the ox to man. It is to be noted that this infection of the ox can only occur in countries where proper sanitary measures for the disposal of human excrement are neglected. The remedy is the provision and use of proper latrines in all communities.

Inspection and Action to be Taken.—The cysts are seen as small rounded semi-transparent sacs embedded between the muscle fibres. They vary in size from that of a millet seed to that of a grain of [illegible]. Sometimes they may be found as a calcified condition similar to that of degenerated tubercles described in the section on Tuberculosis. If the routine inspection (see Section [illegible]) has disclosed infection with *Cysticercus bovis*, further cuts are made into the muscles of the thigh, tongue, heart and diaphragm. The affected parts are seized.

When *Cysticercus bovis* is generalised, the whole carcass should be condemned. In practice it is usual to boil the infected meat for two hours at the slaughter house under supervision. The cysts are destroyed by the boiling and the meat may then be released for human food. Cold storage of the carcass for a period of at least three weeks is also said to kill the cysts.

II. Cysticercus cellulosae.—This is the cystic stage of another tapeworm, *Taenia solium*. The cysts are found between the muscle fibres of the pig, and the adult tapeworm inhabits the human intestine. Except that the intermediate host is the pig instead of the ox, the life history of *Taenia solium* is similar to that of *Taenia saginata*, described above.

Taenia solium may reach a length of 4 to 1[illegible] feet. It may be distinguished from *Taenia saginata* by the presence of a circle of small hooks ("hooklets") on its head. It attaches itself to its host's small intestines with these hooklets instead of by suckers, as does *Taenia saginata*.

Methods of inspection and action to be taken are the same as for *Taenia saginata*.

Parasites which cause Deterioration of Meat, but which are not transmissible to man.

I. Liver Flukes.—These are flatworms about ½ to 1 inch in length and of a brownish colour. They usually inhabit the bile ducts of the liver of their hosts, but are occasionally seen in the lungs, where they cause a tumour. As the result of their presence, the bile ducts

often become greatly enlarged and thickened, standing out as white cords on the surface of the liver In some cases the substance of the organ is not changed, but generally it turns a greyish colour and becomes very firm to the touch If the liver and ducts are cut, the flukes emerge, together with a dark sticky fluid

Flukes are commonly found in the livers of sheep and oxen which have been feeding in wet, marshy places

Action.—The affected organ should be condemned. If the carcass is dropsical or emaciated, it should be condemned

Life History of the Liver Fluke—Like the tapeworm flukes spend their larval stage in one host, **the intermediate host**, and their adult stage in another, the **definite host.**

The cycle is as follows

(a) The adult flukes in the bile ducts of an infected animal are hermaphrodite—i e, each fluke has both male and female organs and fertilizes its own eggs The eggs, having been fertilized, are carried by the bile to the intestine, and are eventually evacuated among the fæces.

(b) If the fæces and eggs are deposited on wet, marshy ground, or in a puddle or other standing water, the egg covering breaks and a very tiny larva about 1/100 inch long emerges, and immediately begins to swim about in a very active manner

(c) The larva, or "miracidium" as it is called, is now searching for its intermediate host, a certain kind of snail which lives in ponds or among damp grass in swampy places If it does not succeed in finding a snail within eight hours, the larva dies, if it does succeed, it bores its way into the snail's body and there becomes changed in form

They reproduce themselves for several generations, and then once again become changed in form They now

have b g round heads and long thin tails and are called *cercariæ*

(f) These cercariæ bore their way out of the snail and swim about for a little while, finally fastening themselves ■ blades of grass and protecting themselves by exuding a substance which completely covers them. This substance hardens and the cercariæ have become encysted.

(g) If a sheep or an ox swallows the grass on which the cysts are fixed the covering ■ digested and the embryos being released creep up the bile duct to the liver There they grow into adult flukes ready to produce eggs and so start the cycle again.

II Hydatid Cysts.—These are the bladderworm or cystic stage of tapeworms (*T echinococcus*), which live in the intestines of dogs The cysts may be found ■ or on the heart, spleen kidneys liver and lungs of pigs, sheep and cattle They vary in size from that of a small bird's egg to that of a hen's egg and contain the heads of the future tapeworms together with some fluid

A heavily infected liver may contain several hundreds of hydatids and may become great y enlarged Sometimes the cysts degenerate and become caseous in this state they may be mistaken for the nodules of tuberculosis. If there is no evidence of tuberculosis in the correspond ng lymphatic glands or in other parts of the carcass or organs it is most likely that such caseous nodules are degenerated hydatid cysts

Action.—The affected organ should be condemned and the carcass passed if otherwise in sound cond tion

Note.—The condemned parts should not be disposed of in any place where they might be eaten by dogs, which are the definite hosts of the adu t tapeworm otherwise the cycle will be completed and the infection will be spread

Human beings may become infected with hydatid cysts but not by eating meat containing them. The infection is carried ■ man by water vegetables, etc., which have been contaminated by the fæces of dogs which are harbouring the adult tapeworm For this reason dogs should not be allowed to enter a slaughterhouse and ■

5 Note any extensive bruising of the carcass

6 Examine the surfaces of lungs, pleura and peritoneum for evidence of tuberculosis or inflammation

7. Palpate the lungs—i e., take them in both hands and squeeze them all over for evidence of tuberculosis, cysts and abcesses

8 Examine the mediastinal and bronchial lymphatic *glands for evidence of tuberculosis If these* are obviously diseased, do not cut them If a cut is made and disease found, **the knife used must be sterilized** before being used for cutting healthy parts of the carcass

9 Open the heart sac (pericardium) and examine the surface of the heart for *Cysticercus bovis*

10 Examine the liver and the hepatic gland for tuberculosis, abscesses, flukes, etc

11 Examine the renal lymphatic gland and *expose* the kidneys Examine the surface and, if necessary, the substance of the kidneys for tuberculosis, etc

12 Palpate the udder and supramammary gland for evidence of tuberculosis, abscesses, etc

13 Examine the intestines, stomach and spleen, and the mesenteric lymph glands for tuberculosis, inflammation, anthrax, etc.

14 Examine the tongue (*Cysticercus bovis* etc) the roof of the mouth (rinderpest) and the pharyngeal, submaxillary and parotid lymph glands (tuberculosis)

15 Cut the muscles of the shoulders, cheeks and brisket, and examine for *Cysticercus bovis*

[illegible]

under the appropriate headings in the previous section

It is important to remember that, *unless it is absolutely* necessary for the purpose of inspection, a carcass must not be cut by the inspector in such a way as to reduce

■ market value If no evidence is found during the routine inspection detailed above the carcass should be passed and should not be cut into any further

Situation of the Lymphatic Glands mentioned in this Chapter

1 Glands to be examined (not necessarily cut) as a routine measure

Lymphatic Gland	*Where Situated*
Mediastinal gland	In the mediastinal tissue between the lungs Close to the œsophagus
Bronchial gland	On either side of the trachea near the point at which it divides into two branches to form the bronchi
Hepatic gland	Near the hilus of the liver
Renal glands	In the fat near the hilus of the kidney
Superficial inguinal (male only)	In the cod fat
Supramammary gland (female only)	Above and behind the udder
Mesenteric glands	A chain of glands in the mesentery parallel with and a little distance from the intestines
Pharyngeal glands	At the root of the tongue near its bone
Submaxillary glands	About 2 inches in front of the point where the lower jaw curves upwards
Parotid glands	At the root of the ear

The above lymphatic glands should always be examined as a routine measure, and if it is considered necessary they may be incised (cut). The proper method is to slice the gland by several longitudinal cuts so that there is little chance of missing any tubercle that may be present

Radiation.—When not obstructed, heat passes away from a hot substance in straight lines, or rays, which spread out in all directions from the source. Heat rays are similar to light rays in this respect, but are not visible. Heat which is travelling in this way is called **radiant heat**.

Radiant heat passes freely through empty space and is not much obstructed by most gases. Most solids and liquids, however, retard the transmission of heat in a greater or lesser degree, the heat being absorbed by the substance which intercepts it. The heat from the sun reaches us by radiation, the rays pass freely through empty space until they arrive at the edge of the envelope of air which surrounds the earth. Dry air allows heat rays to pass through with very little obstruction, and so on a dry day the rays of the sun lose only a small proportion of their heat on their journey through the atmosphere. Water and water vapour, however, absorb a great deal of heat from the sun's rays, and the presence of clouds in the atmosphere makes a noticeable difference to the temperature at the earth's surface.

When the heat rays reach the surface of the earth, they are intercepted and absorbed. They warm the surface. At night, when heat rays from the sun do not reach the earth's surface, the surface, being warmer than the atmosphere, radiates heat back again into space. If the air is dry, this escape of heat from the surface of the earth is rapid and the night temperature is much lower than that of the day. Deserts are very hot in the daytime and cold at night. If, on the other hand, there is much water or water vapour in the air the radiation of heat from the surface of the earth is greatly retarded and the difference between the day and night temperatures is not so pronounced.

Conduction.—Conduction is the passing of heat from molecule to molecule or from substance to substance by actual contact. If one end of an iron bar is put into a fire, the other end becomes hot in time, the molecules which are actually in the fire passing on the heat to their immediate neighbours, and this process being re-

peated until the heat has reached the other end of the bar Note that the part of the bar which is out of the fire does not get as hot as the part which is in it, because some of the heat which passes into it is given off by radiation from the surface into the atmosphere This radiant heat may be felt quite easily if a hand is held at a little distance from the bar

All substances conduct heat to some extent, some much more quickly than others Those which pass heat through themselves very quickly—e g., iron and other metals—are called **good conductors**; others through which heat passes slowly are called **bad conductors**.

Convection.—Convection is the carriage of heat from place to place by heated molecules or particles of a gas or liquid There is no convection in a solid substance because its molecules cannot move about freely When heat travels by conduction through a solid, the molecules do not move out of their place, they simply pass the heat on from one to another When, however, a gas (e.g., air) or a liquid (e g., water) is heated, the molecules nearest to the source of heat become hot and rise, their places being taken by cooler ones and this [illegible]

together For example, in the case of a vessel of hot water, heat is travelling from the hotter parts of the water to the cooler parts by convection, heat is passing from the hot water to the outer surface of the vessel by conduction heat is passing from the outer surface of the vessel through the air by radiation and is also passing into the air which surrounds the vessel by convection

Temperature.—Temperature is the intensity of heat in a body It is not a measure of the quantity of heat which the body contains—e g., 1 gallon of boiling water registers exactly the same temperature as, say, 10 gallons of boiling water although the latter contains ten times as much heat as does the former In other words, 10 gallons of water need ten times as much fuel to raise

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Temperature—Temperature is the intensity of heat in a body It is not a measure of the quantity of heat which the body contains—e g , 1 gallon of boiling water registers exactly the same temperature as, say, 10 gallons of boiling water although the latter contains ten times as much heat as does the former In other words, 10 gallons of water need ten times as much fuel to raise

them to boiling point as does 1 gallon, but when that point has been reached the temperature of the water is the same in both cases. The amount of heat required to raise a mass of water to boiling point depends on the quantity of water. If a body at a high temperature is placed in contact with a body at a lower temperature, heat passes from the hotter body to the colder, until both are at the same temperature.

Heat and *cold* are not different things. *Cold* is a lesser degree of heat, and the word is used to express our sensation when we touch, or are touched by, something which is at a much lower temperature than are our bodies. The normal temperature of the human body is 98.4° F. When a substance feels cold to the touch, it is taking heat away from the hand; when it *feels hot, it is losing heat and imparting it to the hand.* This heat which can be felt is called **sensible heat**, and it is this sensible heat which can be measured by the aid of a thermometer, the result of the measurement being called temperature.

The Thermometer.—The thermometer is an instrument for measuring temperatures or degrees of heat ... gases expand

attached to a long, thin, hermetically sealed glass tube. At low temperatures the mercury fills the bulb and a small portion of the tube. When the mercury is heated, it expands and rises in the tube. *When it is cooled,* it contracts and falls. The scale of temperature is marked

ing ice and then marking the height of the mercury *on the tube.* *If the thermometer* is to be marked in degrees centigrade, this point is called 0° C. If a Fahrenheit thermometer is wanted, the freezing point is marked 32° F. The second is got by plunging the bulb into

boiling water and the height of the mercury ■ marked on the tube this being boiling point In the case of a centigrade thermometer it is called 100° C and in that of a Fahrenheit 212° F

The space between these two fixed points is now divided into equal parts or degrees the number of these being equal to the difference between boiling point and freezing point in each case—i e a centigrade thermometer has 100° between the two points and a Fahrenheit thermometer has 180

How Heat ■ used as a Disinfectant.—Heat may be applied to articles which are to be disinfected in several ways—e g through the medium of boiling water through that of hot air and by means of steam

Boiling Water—Boiling water is an excellent disinfector for articles to which it may be safely applied such as sheets pillow-cases towels articles of clothing which are made of cotton cooking utensils cutlery and so on Note that blankets and clothing made of wool should not be boiled

Hot Air—Hot Air ■ a poor disinfecting agent for bulky articles such as mattresses and bundles of blankets its penetrating power being very weak The surface of a th ck article which is also a bad conductor of heat may be scorched by hot air while the interior remains quite cold and therefore is not disinfected at all Hot air may however be used for destroying lice and their eggs in skins or other articles of clothing which can be arranged in such a manner that the heat has access to all the surfaces

Steam—The use of saturated steam ■ probably the best means of applying heat for the purpose of disinfection to bedding and clothing It penetrates readily into a mass or bundle of blankets or into a mattress and there gives off its latent heat When water is changing into steam it absorbs heat w thout showing any rise in temperature This heat ■ called latent heat and is given off when the steam is changing back again into water (see Chapter II)

Steam Disinfection—There are several types of steam disinfectors but the general principles on which they work are the same and we shall take as an example the—

Thresh Steam Disinfector—This consists of a large steel cylinder lying on its side and having double walls There are airtight doors at each end. This cylinder forms both the disinfecting chamber and the boiler in which the steam in generated The water occupies part of the space between the walls of the cylinder and is heated by a fire underneath. The steam passes into the disinfecting chamber through a pipe The disinfector is usually fixed in a wall between two rooms into each of which one end of the cylinder projects We shall call these rooms No 1 and No 2.

How to Use a Thresh Disinfector—Room No 1 is used to receive only infected articles The doors at this end of the cylinder are opened and the articles are placed inside The doors are then fastened and the steam is turned on and allowed to flow through the disinfecting chamber for about half an hour the exact period depending upon the kind of article to be disinfected and the heat resisting power of the infective organisms When disinfection is completed the steam is cut off [illegible]

are removed Note that if the disinfected articles were returned from the chamber to Room No 1 they would probably become re infected There should be no communicating door between the two rooms

How Steam penetrates a Bundle of Clothing or Bedding—The steam in the chamber comes into contact with the cooler surface of the bundle It is cooled and condenses to water At the same time it gives off its latent heat which is absorbed by the article The water thus formed occupies much less space than did the steam and a partial vacuum is formed into which more steam rushes and condenses as before Each time that

condensation takes place the steam penetrates a little further into the bundle and there gives off its latent heat. This process continues until the temperature throughout the bundle is the same as that of the steam—that is until the heat has penetrated the whole bundle and has thoroughly disinfected it.

Articles which may be best disinfected by steam include blankets sheets clothing mattresses and any articles wholly made of wool or cotton Steam destroys leather articles books and anything in the making of which glue is used If infected articles are stained—e g with blood or fæces—the stains should be removed with soap and cold water before disinfection by steam is carried out otherwise the stains will become permanently fixed

Note that the object of disinfection is to destroy the organisms of disease **without destroying the infected articles.** It is waste of time and money to use a method of disinfection which results in the destruction of the things to which it is applied If the infected goods are of little or no value the cheapest and best method of disposing of them is to burn them thus destroying the organisms and at the same time disposing of unwanted refuse *Such infected articles should never be thrown away or put into a dustbin*

2 **Chemical Disinfectants**—Chemical disinfectants may be applied either in a liquid or in a gaseous form

Liquid Disinfectants.—The most commonly used liquid disinfectants are

(a) Those derived from the distillation of coal tar
(b) A solution of chloride of lime and water
(c) Formalin

(a) Those derived from the distillation of tar include carbolic acid izal cyllin Jeyes fluid, lysol and sanitas They are usually made into a 5 per cent. solution with water and used for spraying rooms soaking infected articles disinfecting discharges fæces and so on

(b) **Chloride of Lime**—This may be made into a 2 per cent solution with water and used as a spray The

spiral horizontally within a small glass jar Pour methyl alcohol into the jar until the surface of the spirit is about ¼ inch from the spiral Warm the alcohol gently Remove the spiral and make it red hot Replace the spiral quickly, and the wire will continue to glow and the acrid smell of formaldehyde will soon be noticed The oxygen of the air is absorbed by the hot platinum, and is then more active than free oxygen, so that when the vapour of the methyl alcohol comes into contact with the hot platinum, it is quickly oxidised and formaldehyde gas is formed

Disinfection or Fumigation with Formaldehyde—For disinfecting purposes the gas is usually obtained from **formalin,** which is a 40 per cent solution of formaldehyde gas in water, containing 15 per cent. methyl alcohol. It may also be obtained from formalin tablets, which are specially prepared for the purpose If formalin is used put 5 ounces of permananate of potash into a deep [illegible] special lamp

Formaldehyde is a safe agent for disinfecting almost anything, and may be used for books, delicate fabrics, leather goods and so on without fear of damage The articles must be well spread out so that the gas may come into contact with all parts, as formaldehyde does not *readily penetrate into bulky articles It is not a good* insecticide, and is, therefore, not used after plague cases

While the gas is being released the room should be closed up, and should remain closed for at least six hours

(b) Sulphur Dioxide.—This gas destroys bacteria, and also vermin such as fleas and rats It is chiefly used for the latter purpose, as it bleaches colours and has a bad effect on metals and on many fabrics For disinfecting and disinfesting purposes it may be used in one of the *following ways*

(a) By burning sulphur in a bucket or similar vessel

about 4 pounds of sulphur being used for each 1 000 cubic feet of air space Not more than 1 pound of sulphur should be burned in any one bucket, and it is advisable to pour a little methylated spirit over the sulphur before setting fire to it.

(b) By burning specially prepared sulphur candles These have wicks which make them easier to light The candles must stand in a strong metal dish, and about 4 pounds should be allowed for each 1 000 cubic feet of air space in the room

(c) By using sulphur dioxide gas in cylinders The air of the room must be moistened by spraying with *water before the gas is generated. Sulphur dioxide is* a heavy gas, and should, therefore, be generated as high up in the room as is practicable—e g , the sulphur might be placed in a bucket on the top of a pile of boxes in the centre of the room The room should be closed during the process of generating the gas, and should remain closed for about twelve hours—longer if possible

General Instructions for Disinfection by Gases.—Whatever gas is to be used for disinfection the following rules must be observed

(a) All joints, spaces and cracks round doors and windows must be covered in such a way as to prevent the escape of gas This may be done by pasting strips of paper, such as old news papers round them after they have been closed The paste may be made by pouring boiling water over flour and stirring it.

(b) All ventilators and other places through which gas may escape must be made gas tight.

(c) If there are any cupboards in the room, the doors of these must be opened so that the gas may enter freely

(d) All articles which are to remain in the room for disinfection must be spread out as much as possible Fabrics, curtains and so on should be hung on lines stretched across the room

(e) If books are to be disinfected, their pages should be well separated so that the gas may reach their surfaces

(f) When everything is ready, the person in charge of the disinfection should leave the room quickly, close the door tightly, and paste strips of paper round it on the outside and over the keyhole

(g) The room should remain sealed for the correct period of time required for disinfection

(h) When this has passed and disinfection is considered to be complete, all doors and windows should be thrown open to allow the gas to escape and fresh air to enter the room

(i) The room should be cleaned in the manner already described as being necessary after spray disinfection

Note that gases do not readily penetrate into dense substances, and should not, therefore, be used for the disinfection of bulky articles such as blankets and mattresses If precautions are taken to prevent leakages, disinfection of surfaces will be accomplished and many micro organisms destroyed

Current Disinfection (see p 198)—This should be carried out continuously by the person who is attending the patient, it includes the following

Discharges from the nose and ears should be received on gauze or tissue paper and burnt immediately

Sputum may be treated in the same way, or may be ejected into a sputum cup which contains a disinfectant, such as a 5 per cent solution of lysol or carbolic acid

Fæces from a typhoid patient should be received into utensils which contain 5 per cent solution of carbolic, formalin or other suitable disinfectant and should be broken up and retained for two hours before being emptied into the lavatory If pit or bucket latrines are in use, the safest way to dispose of such fæces is to bury them in quicklime, after disinfection as above

Infected linen should be soaked in disinfectant for twenty four hours sent to a steam disinfector, or may be boiled for at least one hour

Exercises.

1 What do you understand by the term disinfection"? What is the difference between current disinfec tion and "terminal disinfection ? Which of these two do you consider to be the more important? Give reasons for your answer
2 Distinguish between a disinfectant and a deodorant Name two classes of disinfectants and give examples of disinfecting agents from each class
3 What do you understand by the following terms

process is suitable and also examples of articles of common use which would be destroyed by it
5 How would you disinfect (a) blankets (b) shoes

you would use each of them

CHAPTER VII

COMMUNICABLE DISEASES

Definitions.

1 **Communicable Disease**—A disease which can be transmitted from the sick to the healthy

2. **Contagion**—The transmission of disease from the sick to the healthy by contact

3 **Infection**—A disease producing organism which can be transmitted from one person to another without actual contact

4 **Germ**—Literally the origin or beginning of something In medical language a pathogenic organism

5 **Pathogenic.**—Capable of causing disease

6 **Susceptibility**—A state in which a person is easily affected by a pathogenic germ

7 **Immunity or Insusceptibility**—A state in which a person cannot be affected by a pathogenic germ

8 **Parasite**—Plant and animal organisms which attach themselves to other organisms and get their nourishment from them

9 **Host.**—An organism from which a parasite gets its nourishment

10 **Incubation**—A hatching out—e g a hen sitting on her eggs In medical language the development of a germ of disease within the body

11 **Incubation Period.**—The time that elapses between the entry of a germ and the appearance of the signs and symptoms of disease

12 **Lesion**—A wound or injury A structural tissue change due to disease

13 **Quarantine**—The isolation of a place or person on account of infectious disease

14 **Epidemic.**—A disease which attacks a great number of people in the same place at the same time

15 **Pandemic.**—An epidemic which spreads all over the world

16 **Endemic Disease**—A disease which is always present in a district

17 **Hyperendemic Disease**—A disease which is always excessively prevalent in a district.

18 **Epizootic.**—A disease prevalent among animals comparable to an epidemic among men

19 **Sporadic.**—A disease usually epidemic attacking only a few in a district and not spreading

20 **Specific Disease**—A disease which is caused by a germ peculiar to that disease

Introductory

About the middle of last century the causes of communicable diseases were discovered to be living microscopic germs. Prior to this time nothing was known of disease germs and very little about how to avoid infections. The importance of segregation was known for lepers were cast out and people ran away from pest bendden places. Immunity following infectious diseases was also known and protection against smallpox by vaccination was practised but why immunity was conferred no one knew.

Following their discovery, disease organisms became the subject of intense study all over the world. Their habits of life and the ways by which they gained entrance to our bodies became known. Thus it was possible to devise means of avoiding infection. Knowledge of those conditions which favoured or retarded their growth has for example, taught us that by removing filth and dust and by admitting ample sunlight into our homes disease germs can be abolished, knowledge of how the germs are transmitted from the sick to the healthy has enabled us to protect ourselves against infection even when we are exposed to it.

Until very recent years apart from doctors and those whose work it was to study disease germs very few people had any knowledge of them, and it was soon found that for the protection of people at large preventive measures against the spread of disease had to be devised and enforced upon them. Such measures could be instituted and enforced only by the authority of the State and so it came about that in all civilized countries Departments or Ministries of Health were formed.

Functions of a Health Department.—A Department of Health is directed, as all other Government departments are from central offices at the seat of government. Its activities are broad and widespread varying in different countries according to the state of the country's advancement in industrial and social life. In no country however can a Department of Health perform its functions efficiently unless it interests itself in a number of essen

tials which includes the provision of sanitary dwellings and efficient drainage, the protection of water supplies from the risk of infection, the supervision of food supplies, the notification and control of communicable diseases, and vital statistics from which information is obtained regarding the general health and welfare of the population Among other interests are maternity and child welfare, inspection of factories and workshops the control of offensive trades and nuisances, and, indeed, any organization which is conducive to improvement of the public health generally

It will be seen that a department with such varied activities could not achieve its purpose without close co operation with other departments The Legal Depart ment with the guidance of the head of the Health Service frames the Public Health Acts and Ordinances which make compliance with rules and regulations com pulsory The Public Works Department provides water supplies, sewage, schools, hospitals, etc The Education Department assists by spreading the gospel of health and hygiene among the young The Veterinary and Agri cultural Departments are concerned with the control of disease among foodstuffs and with the production of good qualities of food.

Staff of a Health Department.—In most British colonies and dependencies the head of the Health Depart ment is the **Director of Medical Services**, who has a seat in the Governor's Council, and whose duty it is to advise on all matters pertaining to public health and to co ordin ate with other official departments in carrying out approved schemes

On the staff of the D M S are the **Medical Officers of Health (M O.H)**, who are doctors specially trained in public health, and who must hold the special diplomas of their training schools It is their duty to safeguard [illegible]

sion of housing conditions, schools, water supplies and

above all the control of spread of infectious diseases and reporting their occurrence to the central authority, the D.M.S.

Under the Medical Officer of Health there may be a number of specialist officers whose duties are the investigation and control of certain communicable diseases such as sleeping sickness, plague, tuberculosis, venereal diseases and others.

Assisting the Medical Officer of Health are Sanitary

of samples of water and food for examination and above

follow this practice. Local Authorities maintain their own services and engage their own staff. This practice is much to be commended for it is more satisfactory for the local people to have full responsibility for measures undertaken to protect their health and social welfare.

Statutes and Orders.

Public Health Acts.—Public Health Ordinances are periodically

meeting places, shops and factories, they stipulate the

requirements for proper sewage disposal and drainage they legislate for the abolition of insanitary dwellings and nuisances, for the prevention of overcrowding for the protection of children, and for many other activities which are conducive to health.

Infectious Diseases Notification Acts—The control of infectious disease is dependent on early notification It is thus made compulsory by law for people who recognize such infectious diseases as are notifiable to report their occurrence along with the name and address of the patient, without delay

The diseases which are notifiable vary in different countries It would, for instance, be absurd to make a disease like malaria notifiable in a hyperendemic area On the other hand it would be important that it should be made notifiable in a country where the disease has been stamped out by control measures for the occurrence of one case might well be the cause of an epidemic The diseases which are notifiable in most countries are as follows

Smallpox	Encephalitis lethargica
Cholera	Poliomyelitis acute
Diphtheria	Erysipelas
Scarlet Fever	Typhus fever
Typhoid group	Puerperal fever
The dysenteries	Relapsing fever
Plague	Cerebro spinal meningitis
Tuberculosis	Leprosy
Ophthalmia neonatorum	Measles
Chickenpox	Anthrax, etc
Acute pneumonia	

Spot Maps—A spot map is a map of a district in which an outbreak of infectious disease has occurred on which, by means of a flag or other mark, the sites of the occurrence of infectious cases are marked as they arise By such a contrivance, combined with careful investigation into the distribution of water, milk and food supplies, the source of the outbreak can often be traced The direction of the spread of the disease often provides a clue to the source

Vital Statistics—Registration—Every ten years the population is counted—i.e a census is taken Every

persons who die in every thousand of the average population of the year This is called the **crude death rate** Corrected and standardised death rates are special rates calculated from the crude rate in accordance with the places of residence of individuals at the time of death and of age groups respectively

The Birth Rate.—The birth rate is a similar calculation—viz. the number of births registered in a year per thousand of the population for that year

Registration of Births, Marriages and Deaths—Births must be notified whether the child is dead or alive within a certain period usually six weeks from birth Marriages and deaths are registered also

Infantile Mortality Rate—This is the number of deaths of infants occurring under one year old per thousand of births registered during the year

Isolation Hospitals, Quarantine and Immigration Camps.

Isolation—Powers are given also by law for isolation of infectious patients and for the control of contacts Infectious patients are isolated in special hospitals which are usually separate from other hospitals and at some distance from concentrated populations In the case of a highly infectious disease such as smallpox special

ships.

Contacts may be obliged to live in camps until they are declared immune or have passed the incubation period without showing evidence of contracting the disease

In some cases contacts are placed under **surveillance**, which means that they are allowed their freedom but must *report periodically to a doctor*, so that the first signs of disease may be recognised and that they may be isolated

An isolation hospital is a hospital in which infectious cases are nursed

A **quarantine camp** is a camp in which contacts are accommodated while under observation

An immigration camp is a camp where immigrants from a country in which an infectious disease is prevalent are isolated until the incubation period has been completed

Port Sanitation—*The sanitary regulations relating to* shipping on entering ports are designed to prevent the importation of infectious disease All ships are on arrival visited by a Port Medical Officer of Health who inspects the ship's papers to discover any record of ill health among the passengers and crew If cases of infectious disease be suspected, they are isolated on [illegible] *In the case of* [illegible] sec- [illegible] ted [illegible] cial [illegible] om [illegible]

The duties of a Sanitary Inspector in relation to shipping *are those of disinfection* and disinfestation performed under the direction of the Port Medical Officer

In view of the rapidly increasing numbers of passengers carried all over the world by aircraft, the importance of air transport in the transmission of infectious diseases cannot be too stongly stressed *The* duties of a Health Inspector in relation to aircraft are *the same as those connected with shipping* but as transport from one country to another is rapid ordinarily well within the incubation period of dangerous infectious diseases he must act with special caution Aircraft coming from known endemic areas must be most carefully examined to *ensure that no insects likely to carry*

disease are brought in the aircraft. It is the general practice, for example, to have an aircraft arriving from an area where yellow fever is endemic completely cleared of all insect life by an approved method.

Most governments insist that persons coming by air from areas where the more serious infectious diseases prevail are fully protected by inoculation or vaccination before they are allowed to land. Plague, cholera, typhus fever and smallpox are regarded as serious infectious diseases. It is the duty where such regulations exist for the sanitary inspector to examine certificates and to see that they are in order. In countries where protection by inoculation is not insisted on, passengers may be allowed to land under surveillance, after giving their addresses while in the country. The Sanitary Inspector then notifies the Health Authority of the area to which the passenger is proceeding. The passenger is then kept under observation during the incubation period of the disease which he may be carrying.

Village and Rural Sanitation.

Selection of Sites.—As in the choice of a site for a dwelling (Chapter III) the nature of the soil, drainage, cleanliness, elevation and absence of nuisances and insect infestation should be taken into account.

[illegible]

lation.

Rest-houses.—People on trek may become infested by lice, ticks, fleas and bugs. Rest houses should, therefore, be sited outside the village, and should have cement floors and smooth walls to prevent the harbourage of

vermin Bath houses and latrines for both sexes should be provided

Sanitary Plots.—The siting of latrines and refuse destructors require considerable thought If individual latrines are dug they will be sited in the compounds of the huts If a communal latrine is used, it should be sited in an accessible position and should be screened from the public view *Separate accommodation should* be provided for both sexes Constant inspection is required to maintain cleanliness and freedom from smell Latrines and incinerators are described in Chapter IV

Roads—Roads should be surfaced and cambered for drainage They should be wide

Disposal of the Dead.

Burial—In disposing of the dead by burial, certain sanitary principles have to be observed Burial grounds should not be close to dwellings, they should not be on high ground from which drainage may contaminate water supplies, they should not be on low lying ground which is liable to be encroached by streams

Bodies should be buried deep enough to prevent [illegible]

the fissures

In estimating the space required for a cemetery, 1 acre of ground is regarded as a minimum per thousand for a period of fifty years

One of the principal objects of burial is rapid decomposition and absorption of the products Shallow burial in suitable soil hastens decomposition, and provided exposure by animals is guarded against, this is ideal. The use of coffins retards the process

Cremation—Cremation, properly performed, is the most rapid and efficient method of disposal of the dead It is, however, expensive, and if it is improperly per

formed on account of lack of fuel and the charred body is left exposed it is most insanitary

Exposure.—Simple exposure by depositing bodies on the ground to putrefy and stink is wholly insanitary

The Causes of Communicable Diseases.

Communicable diseases are caused by pathogenic organisms which are parasitic on the human body They are low forms of plant and animal life When they gain entrance [illegible] the body they multiply and produce poisonous substances The body tissues resist their invasion by undergoing changes which destroy the organisms and counteract their poisonous secretions or **toxins.** These changes in the tissues give rise to sensations of discomfort and pain the **symptoms** of disease They also cause visible changes such [illegible] rashes and swellings and other conditions which can be discovered only by a doctor, these are spoken of as the **signs** of disease

Each pathogenic germ produces signs and symptoms which are more or less characteristic Thus by a study of the signs and symptoms the disease is recognized and the causative germ is known

The pathogenic bodies belong to five groups—**viruses, rickettsiae, bacteria, protozoa** and a number of animals which are commonly spoken of as **animal parasites.**

The viruses—Very little is known about viruses Most of them cannot be seen even with the highest powers of the microscope and most are so small that they can pass through the pores of the finest filters

Virus diseases are transmitted by **contagion** and by **inoculation.** Examples are measles, smallpox, chicken pox and mumps, which are contagious, yellow fever which is inoculated by infested mosquitoes and rabies by the b[illegible]

[illegible]

by inoculating people with a preparation of the virus

Smallpox, for example, can be warded off by vaccination with *cowpox lymph*, the virus of the cowpox lymph is probably the same as that of smallpox but altered and made less virulent by passing through the cow

The Rickettsiæ—The Rickettsiæ are very small germs which occupy a position between viruses and bacteria They give rise to various forms of *typhus fever* and are transmitted by several kinds of insects

Bacteria.—Bacteria are universal Fortunately, all are not pathogenic, many are harmless and some are actually useful, such as those that live in our intestine and help the digestion of our food.

Bacteria can be seen under the microscope They are many sizes and shapes Some are seen as mere dots cocci, others in the form of minute rods, bacilli, others like corkscrews, spirilla, Some arrange themselves in [illegible] They vary too in

[illegible]

in *Some can move, others cannot* The colonies in which they grow have characteristic appearances Different types, when stained for examination under the microscope, *stain differently*

Thus we can identify bacteria by their shapes, habits of life and their staining properties They are commonly named *after* the name of the disease which *they produce* The pneumoccus for example, is the cause of pneumonia the tubercle bacillus the cause of tuberculosis

Some bacteria multiply by simply dividing their bodies, the two halves grow and become adults, and they continue to multiply in this way Others multiply by forming spores

Some are unable to resist adverse conditions and are easily killed, others protect themselves in a number of ways The tubercle bacillus, for example, has a very tough skin and so can resist drying the tetanus bacillus forms minute spores which are very hard to kill

Examples of bacterial diseases are typhoid fever, plague, dysentery, syphilis, gonorrhœa and many others

Protozoa.—*Protozoa* are nucleated single-celled animals They are much larger than bacteria and have a

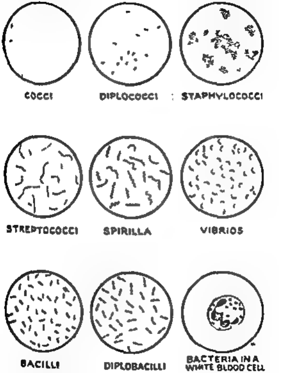

FIG 67 —TYPES OF BACTERIA AS SEEN THROUGH A MICROSCOPE Highly magnified

definite structure They can move some by amœboid movement, others by means of fin like appendages while

WORMS

Round

Ascaris lumbricoides
Threadworm
Hookworm

Trichina spiralis
The filarial worms
Ankylostomes

Tape

Tænia saginata
Tænia solium
Tænia echinococcus

Flat

Schistosomes

Insects

Lice head body and pubis
Fleas
Mosquitoes
Flies house, tsetse, sand

Arachnids

Ticks *Ornithodorus moubata*
Mites *Saracoptes scabiei*

The Effects of Infection on the Body.

Disease germs enter the body mainly by way of—

(1) The respiratory tract influenza, smallpox, etc
(2) The food canal, typhoid fever, dysentery, etc
(3) The skin by bites or through abrasions malaria yellow fever, syphilis

When the infectious germs have entered the body, the individual may or may not develop the disease If he be susceptible and the organisms be virulent, an attack of the specific disease will follow, if he be not susceptible —that is, if he has a natural or an acquired immunity— he will not develop the disease Shortly we shall first describe what happens in one who develops the disease

Incubation Period.—On entering the body, the infectious germs multiply and produce poisonous substances called **toxins**. For some time, however, the individual is not aware of their presence and there is no evidence that he has been infected This period is known as the **incubation period.** Some diseases have a very short incubation period cerebro spinal meningitis, for example, takes only one to five days after infection before symptoms and signs appear, measles takes ten to fourteen days, while syphilis may be from three to six weeks

Each disease has a more or less constant incubation period This is an important fact, because when people have been associated with an infectious disease they are liable to develop it, and so they are segregated and kept under observation up to the end of the incubation period The length of the incubation period determines the period of isolation or quarantine People who have been exposed to infection are called **contacts.**

The Disease.—At the end of the incubation period the body reacts in defence against the invasion of the germs and the signs and symptoms of the disease become apparent. The way in which the body reacts and the time taken to recover are characteristic in each disease Thus, from a study of the signs and symptoms and the duration of the reaction we recognize the disease and know the nature of the infection Influenza, for example, runs a very short course of a few days, typhoid continues for three or four weeks, and diseases such as leprosy and syphilis continue throughout life Each, too, manifests itself in a characteristic way by affecting the various tissues always in the same manner

The Cure—The termination or cure of a disease results from the defensive reactions of the body High fever, increased white blood cells and the production of antibodies are the principal ways by which the tissues overcome the infectious germs The natural defensive reactions can be assisted by drugs which in many cases have specific curative actions examples are quinine in malaria and salvarsan in syphilis.

How Communicable Diseases are Spread.

Disease is spread by many agencies from the various *discharges that come from the sick*—e g , mucus from the mouth and nose, scales of peeling skin resulting from *rashes, secretions from open sores*, and fæces and urine Infected blood is carried by biting creatures

The agencies by which the germs are carried may be summarized as follows

1 **From fæces and urine**—by contaminated food and water, by flies, by dust and by carriers
2 **From the mouth and nose**—by droplets of moisture, contact with feeding utensils and soiled linen, by sputum and by carriers
3 **From the skin**—by dust, clothing and by contact.
4 **From the blood**—by blood-sucking parasites mosquitoes, fleas and lice

Fæces and Urine—Insanitary disposal of fæces nd urine is one of the commonest sources of infection. Flies which feed both on food and filth pass constantly from one to the other, bearing germs both on their legs and in their stomachs Fæces dry and mix with dust The dust blown on unprotected food contaminates it Water passing over fouled ground also becomes infected and passing into unprotected water supplies, renders the supply infectious Diseases which are spread in this way are typhoid fever, dysentery, cholera and simple diarrhœa

Droplet Infection.—Discharges from the throat and mouth are peculiarly infectious, especially in the early stages of disease In speaking, sneezing or coughing a [illegible] The fine droplets [illegible]

free ventilation, [illegible] reduced Diseases which are spread by droplet infection are measles, mumps, influenza, cerebro-spinal fever, whooping-cough, acute poliomyelitis, scarlet fever and diphtheria Pneumonic plague, a very fatal disease, is also readily spread in this way, so much so that attend

ants must, in nursing this disease, take special precautions by wearing masks over the mouth and nose

Sputum.—Patients suffering from infectious disease are always provided with sputum cups. These should have a little disinfectant fluid in them. Sputum when expectorated on the ground dries, and organisms get mixed in the dust. Some which resist drying are carried on the dust particles, and when blown by the wind they settle on exposed food or may be inhaled. The tubercle bacillus is carried in this way.

Skin Lesions.—Dried scabs and scales from the skin drop on the ground and are blown about. Smallpox and chickenpox may be spread in this way. Contact with secretions from sores on the skin and mucous membranes accounts for the spread of such diseases as syphilis and gonorrhœa.

Carriers—Human Carriers.—Many people carry pathogenic germs and discharge them without themselves suffering from the disease. For example the germs of cerebro-spinal fever are frequently found in the noses of people who have never had the disease. Such people sleeping at close quarters with others are liable to infect them, and they are called carriers.

There is another type of carrier however. During the incubation period in a person about to develop a disease and for long periods after recovery from the attack the germs are carried, and during these periods the patients are very infectious. Typhoid germs may be carried for years after an attack. They are passed in the urine and fæces. Such people would be extremely dangerous in a cook house or in handling food in any way.

Diseases commonly transmitted by carriers are typhoid fever, cerebro-spinal meningitis, scarlet fever, diphtheria and dysentery.

Insect and Other Animal Carriers.—Insects suck infected blood, and passing on to healthy persons bite them and inoculate the germs of disease. Rabid dogs spread rabies by biting. Ticks spread relapsing fever. Other diseases spread in this way are malaria, yellow fever, sleeping sickness and plague.

Disease	*Incubation*	*Isolation*	*Quarantine*
Measles	10 14 days	14 days	16 days
Whooping cough	8 20 days	6 weeks	3 weeks
Mumps	17 21 days	3 weeks	3 weeks
Enteric fever	7 21 days	Until the fæces and urine are declared free from infection	23 days
Typhus fever	12 days	4 weeks	2 weeks
Smallpox	12 14 days	Till all scabs have separated	21 days
Chickenpox	17 days	Till all scabs have separated	21 days
Cerebro-spinal meningitis	1 5 days	Till one week after temperature is normal	10 days
Dysentry	2 8 days	Till one week after the temperature is normal and examination of the stools is negative	14 days
Malaria	8 10 days	Nil	Nil
Influenza	1-4 days	Till complete recovery	7 days
Syphilis	2 6 weeks	Infection is controlled by treatment with salvarsan substitutes	—
Gonorrhœa	3 5 days	After declared free from infection by laboratory examinations of secretions	—

Disease	*Incubation*	*Isolation*	*Quarantine*
Plague	2 5 days	Absolute until recovery	5 days
Cholera	1 5 days	Until vibrio is absent from excretions 7-14 days	7 days

In any form of communal life, however, a carrier is a danger The recent victim of infectious disease is usually known and can be controlled, but the carrier who is not aware of harbouring and discharging pathogenic germs is a serious menace For this reason precautions, enforced by law, are taken when people live in townships or in communities, as in prisons, schools and barracks, to provide in dwellings sufficient air space and ventilation to minimize the risk of infection Cooks and servants who are concerned with the preparation and handling of food may be examined by laboratory methods to discover whether they harbour the germs of disease On the outbreak of any serious infectious disease immediate segregation of patients and contacts is ordered and a search may be made for possible carriers

Control [redacted] Insect-borne Disease—The prevention of spread of insect borne disease is dependent on two factors

The Diseases.

Just as individuals are immune to certain infectious diseases, so also are races Diphtheria and scarlet fever for example, which are much-dreaded and prevalent diseases among Europeans, do not occur in Africans—at any rate, in epidemic form Others are modified in their severity, measles, for example, is in the African rarely severe and practically never complicated by inflammation of the lungs, so common in Europeans

Prevention of Spread.—This disease is virulently *infectious When epidemic, people should avoid crowded* places Ample ventilation, warm clothing at nights and good food help in warding off infection In institutional life influenza spreads through the population with great *rapidity All sick should be segregated*, for this is a dangerous disease, pneumonia of a very fatal type often complicates influenza

Hydrophobia.

This is an infectious disease which is always caught from the bite of a rabid animal Dogs, wolves jackals and monkeys are the common carriers The onset of *symptoms occurs from one to six months after inocu* lation. The patient becomes excited and cannot swallow Severe spasms develop, and are followed by coma and death Hydrophobia is a virus disease

Incubation—*One to six months*

Isolation—Not necessary

Quarantine for Contacts.—Nil

How Spread.—By the bites of rabid animals only

Prevention of Spread—*Rabid animals are destroyed Where the disease is prevalent, dogs should be muzzled*, the movement of unaffected dogs is restricted and strict quarantine for dogs imported from an infected area is enforced

Typhus Fevers.

Under this term is grouped a number of fevers caused by *germs called rickettsia transmitted from man to man* by lice fleas, ticks and mites The fevers often come on suddenly with headache and great weakness A rash usually appears between the fourth and the sixth day *The disease may occur in mild form especially in those* protected by inoculation

1 **Classical Typhus** is louse borne and is a serious disease with a high mortality The disease is associated with dirty personal habits and occurs among people who harbour lice on their clothes or person

Incubation—From six to fourteen days, commonly twelve days

Isolation —Four weeks, the patient being deloused and kept in a louse free room

Quarantine for Contacts—Fourteen days after being deloused.

How Spread.—The infection is passed by the louse moving from the patient to a healthy person. The infected louse passes the infection either by its fæces or by being crushed *the infection entering through scratches* which may be minute, in the skin

The disease is not rare in prisons especially if over crowded, among troops on active service or among pilgrims gathered together at religious centres

Preventive measures.—It is obvious that the first thing to do is to get rid of the lice from the infected person contacts and from the large population likely to be contacts.

Clothing, including blankets, should be disinfected in high pressure steam disinfectors having been put into [illegible]

oily substance, special attention being given to seams

Staff employed on delousing should be protected by wearing gum boots, tight fitting overalls and skull caps Their clothing should be treated with DDT and they should be immunised by inoculation with an approved vaccine

Immunization.—Vaccines for immunization are available and should be used They have been proved to reduce the risk of infection It is not yet known how long inoculation protects but where there is continued risk re immunization should be given at least every six months.

2 **Murine or Rat Typhus.**—This is a fever which is similar to that of Classical Typhus but generally milder

in type The infection is primarily one of rats and especially of the large grey rat The disease is transmitted to man by the flea much in the same way that plague is transmitted. So far as is known the disease is not transmitted from man to man

Preventive measures.—As in rodent control for plague, giving special attention to the grey rat which lives near residential buildings and wanders around at night

3 **Scrub Typhus.**—In this disease the fever is acute and the rash occurs on the trunk, spreading later to the limbs The disease is spread by a mite in its larval stage and a small ulcer may be found where the infected mite attached itself to the body The disease is not infrequently fatal The infection is passed from one generation of mite to the next and is maintained by feeding on susceptible rodents in the main mice and rats The disease is not directly communicated from man to man

Prevalence—Scrub typhus occurs in localities in many countries in the Far East including Japan and Northern Australia It was very prevalent among the troops in the recent war in Burma and Malaya

Immunization—There is no known method of immunization but an attack confers immunity which is not always permanent

Method of Control.—No special measures need be

approved insect repellants will protect the individual.

4 **Tropical Typhus.**—In various parts of the Tropics other fevers generally believed to be due to rickettsia occur They are known to be transmitted by ticks dog ticks being implicated

Method of Control—Animals in contact with man should be treated for ticks

5 **Rocky Mountain Spotted Fever**—This is a tick borne disease occurring specially in North and South America

fection of th- patient s clothing bedding and house and of any place visited by him in the early stages of the disease must be thorough

Nurses and all concerned with a smallpox hospital must be isolated too

Vaccination—Vaccination is the inoculation of lymph from the vesicles of cowpox artificially produced in calves The virus of cowpox is thought to be the same as that of smallpox but rendered less virulent by passage through the cow

It is prepared in the following way A healthy calf is prepared by shaving the skin from its abdomen It is scratched on the shaved area and the virus of cow *pox is rubbed in In about a week the vesicles of cow* pox appear They are scraped off and ground up with glycerine and some mild disinfectant The calf is then killed and examined carefully to ensure that it did not suffer from any disease If found to be diseased the lymph is discarded Further tests are made to ensure that the lymph contains no disease organisms apart from the virus Finally a rabbit is inoculated and if no un toward results follow the lymph is placed in a sealed tube and issued for use

The procedures in vaccinating man vary according to individual fancy A common one is as follows The vaccinator washes his hands thoroughly An area of skin is selected usually the upper part of the arm It is washed thoroughly with soap and water and dried

The glass tube containing the lymph is broken One or two drops of lymph are placed on the clean area when dry at intervals of 1½ to 2 inches The skin is then put on stretch and one or two scratches are made with a needle or other instrument which has been sterilised by boiling or burning in a spirit flame The scratches should be superficial and blood should not be drawn. The lymph is then allowed to dry The lymph while drying should not be exposed to sunlight or dust.

On the fourth or fifth day following vaccination a vesicle forms It enlarges and forms a circular bleb of a pale grey colour On the eighth or ninth day it

becomes purulent and the skin around becomes red About the tenth or eleventh day the pustule dries and forms a scab At the end of three weeks the crust falls off, leaving a depressed scar This constitutes a successful vaccination and gives immunity to infection by smallpox.

If a vesicle and pustule does not form, the vaccination is not successful. The lymph may have lost its virulence, it may have been rubbed off, or the inoculation may not have been properly performed It must be repeated.

If the person protected is already immune by reason of having had smallpox or by previous vaccination, there is invariably a feeling of itching around the scar within 24 hours and redness is apparent within 48 hours or 72 hours which passes away rapidly This itching and early redness can be taken as evidence of the person being protected

Vaccination when successful gives protection for a number of years and sometimes for life but most Health Authorities now require re vaccination within periods of three years as evidence of continued protection

In countries where vaccination within the first year of birth is compulsory and where re vaccination is carried out consistently at seven year intervals, epidemics of smallpox cannot occur Nurses and attendants in smallpox hospitals must be re-vaccinated more frequently for safety

A person contracting the disease when the effect of immunization is passing off never suffers in the same way as those who are unprotected Further, if an unvaccinated person exposed to infection is vaccinated at once, he will be fully protected on the tenth day but if the disease appears before then, it will be milder in its attack than if he had not been vaccinated at all

Dengue.

Dengue is an insect borne virus disease It is carried by Aëdes, and is characterized by a short period of fever and severe limb pains, which go, but recur in three to four days with the appearance of a rash.

Incubation—Two to five days

Isolation—Nil.

Quarantine for Contacts.—Nil

How Spread.—Most people carry pneumococci, the cause of this disease, in their nasal passages What causes the germ to become pathogenic is doubtful. Exposure to cold and adverse conditions of life lower the resistance and probably allow the germs to invade the body

Normally pneumonic cases are not isolated. They are nursed in the open wards of hospitals where ventilation is *adequate and precautions by disinfection are efficient.*

In labour camps, prisons and schools where people live in close contact with each other, pneumonia is liable to become epidemic Careful watch should therefore be kept for early evidence of the disease, so that the affected may be removed at once The disease is spread by droplet infection, which is aided by bad ventilation and overcrowding

It is noteworthy that pneumonia outbreaks are often associated with cold dry seasons Dust and inadequate warmth at night probably have an influence in propagating the disease

Prevention of Spread—Ample spacing in dormitories efficient ventilation sufficient bed clothing in cold weather, good food and hygienic conditions generally combined with segregation of the sick and dust control, are essentials in confined communities These subjects are discussed elsewhere in this manual

Gonorrhœa.

Gonorrhœa is a disease of the genital organs The infecting germ is a bacterium It is transmitted by contact, usually at coitus, and causes acute inflammation of the tissues infected by it. It tends to spread throughout the genital organs in both male and female, often destroying them It may spread through the body, causing severe inflammation and stiffening of the joints The eyes can be infected and blindness often results

Incubation—Three to five days

Isolation—Patients suffering from gonorrhœa are not isolated in the ordinary sense, but they should be prohibited sexual intercourse

How Spread.—Gonorrhœa is spread mainly by promiscuous sexual intercourse Infection of the eyes is caused by using towels, etc soiled by gonorrhœal pus The eyes of newborn children may be infected during passage through the genital orifice at birth

Prevention of Spread.—Indiscriminate sexual intercourse being the principal—indeed, the only—source of genital infection, the obvious safeguard is abstinence This, however, is a question of morals Disinfection

tor and the midwife

In some countries prostitutes are controlled and are examined at frequent intervals, but experience shows that control by no means provides security against infection

In the discovery of the sulphonamide drugs and penicillin we have an efficient aid to prevention of spread for the administration of these drugs leads to an almost

Syphilis.

Syphilis is conveyed by inoculation of a spiral-shaped organism At the site of inoculation a hard sore arises in from two to six weeks The infection then spreads throughout the body, and in from five to eight weeks after the primary sore developed sore throat and skin eruptions appear These continue for about a year after which deeper lesions occur, affecting all parts of the body

Incubation—Two to six weeks

Isolation—The disease is spread by contact with infectious discharges only, therefore the patient is not isolated in the ordinary sense.

urine and sputum, and care of the clothing and feeding utensils But this is the province of the nursing staff. The sanitary inspector is concerned more with the discovery of how and where the first case became infected, and how and where subsequent cases arose

The movements of the patient prior to falling sick should be traced Enquiries should be made whether any suspicious cases had previously been reported. Who supplied his milk, from where he got his water supply, was his house in a sanitary condition, how are the night soil and urine disposed of, what is the state of his latrine are there many flies—these are the questions which he must be able to answer The search for the origin of any outbreak is often one of great difficulty, and usually falls to the sanitary officer himself In this disease more than in any other the human carrier is often responsible and must be traced

Contacts are placed under surveillance, and report as required to the sanitary authorities for examination

Protective Inoculation—Protection by innoculation can be given against enteric diseases Contacts, nurses and hospital staff associated with patients should be protected When epidemics occur, the population should be protected also The inoculation should be repeated when necessary, as the protection lasts for a year only Protection is not absolute, the disease does occasionally affect the inoculated, but it is always mild and its duration is shortened

The Dysenteries.

1 **Amœbic Dysentery.**—Amœbic dysentry is a chronic protozoal disease It is characterized by recurrent attacks of colicky pains and diarrhœa Usually there is no fever As the disease progresses the fæces become mixed with blood and mucus After periods of quiescence relapses occur The amœba, *entamœba histolytica* which causes the disease produces ulceration in the large intestine When active it is amœboid, but resting it encysts itself Both amœbæ and cysts are seen in the stools when examined microscopically

Incubation.—Unknown

Isolation—The patient is infectious when the disease is active and also in the quiescent periods when he passes cysts

Quarantine for Contacts.—Nil.

How Spread.—The same as in typhoid fever Carriers are common

Prevention of Spread.—As in typhoid fever—namely by barrier nursing, investigation of milk and water supplies discovery of carriers and preventing contact with excreta by flies

2. **Bacillary Dysentery**—Bacillary dysentery is an acute bacterial disease There is fever toxæmia acute colic and severe diarrhœa with the passage of blood and mucus often without any fæces Tenesmus (straining at stool) is often severe

Incubation—Two to eight days

Isolation.—Till one week after the temperature and stools are normal

Quarantine for Contacts.—Contacts are not quarantined in the tropics

The method of spread and preventive measures are as for typhoid fevers

Cholera.

This disease is rightly listed among the most dangerous of communicable diseases The causative agent is the cholera vibrio, a comma shaped germ which is found in the bowel and excrement of the person affected In mild cases diarrhœa may be the main and only symptom In the serious cases, which are the typical ones the diarrhœa is continuous and the stools are watery and whitish—spoken of as rice water stools Abdominal pain and vomiting is severe There is thus dangerous loss of body fluid The patient becomes dehydrated, a state which leads to coma and death

Incubation.—From a few hours to 5 days—usually 3 days

Quarantine of Contacts.—5 to 7 days.

Isolation of Cases.—Until the vibrio is absent from the bowel discharges—usually 7 to 14 days

How Spread.—Spread is usually due to contamination of water supplies by excrement from infected persons. Vegetables and food including milk coming into contact with contaminated water and personal contact with the excrement of affected persons are the usual sources of infection Domestic flies are also carriers of infection

Prevention of Spread—Early recognition of the disease and confirmation by microscopic examination of the stools are important Patients must be isolated if possible in fly proof rooms Immediate disinfection of the stools and vomit by strong disinfectants or by burning are essential measures All articles used by the patient or in any way soiled should be put into disinfectant before being taken out of the room All food which has been in contact with the patient must be burned When the patient is discharged the room must be disinfected

Quarantine of Contacts—At least 5 days and confirmation of freedom from the disease by examination of the stools for vibrios

General Measures—Should an area become infected, the sanitary inspector must ensure that all water supplies are made safe from infection Shallow wells and pools are particularly liable to become infected. All water used for drinking, cooking, washing and bathing must be boiled and kept in covered receptacles Only cooked food should be eaten and after cooking it must be protected from flies Every possible measure should be taken to control flies

Immunisation—A vaccine against cholera is available [illegible] ble should be [illegible] population [illegible] y inspectors [illegible] uld be protected

Cerebro-spinal Fever.

Cerebro spinal fever is an infectious bacterial disease with a high mortality It begins frequently with headache and symptoms of fever, just like influenza Stiffness of the neck follows and the head is frequently drawn

ack Delirium and coma precede death A great variety of nervous symptoms may occur in this disease

Incubation.—One to five days

Isolation—The nose and throat secretions are infectious in the first week of the disease

Quarantine for Contacts—Nil

How Spread.—Droplet infection from carriers is the usual method of spread, and, curiously enough, infections from cases suffering from the disease are extremely rare

Prevention of Spread.—Control of this disease [redacted] exceedingly difficult, as carriers are mainly responsible for its transmission and as carriers are common quarantine would be out of the question In epidemic periods the carrier rate may rise [redacted] 20 per cent of the population

The disease occurs in epidemic form mainly in confined communities as are found in barracks, mental [illegible] pro [illegible] educe [illegible] sleep alternately head to the top and head to the bottom of the beds This places a greater space between their respiratory passages which harbour the infection Further, sanitary inspectors dealing with an outbreak should always bear in mind that the patient is most infectious [redacted] the early stages and that the earlier the treatment the better the results both good reasons for immediate removal [redacted] hospital on the slightest suspicion that he has got the disease

Acute Poliomyelitis.

This [redacted] an infectious disease caused by a virus. It affects the nervous system, causing paralysis of various parts of the body

Incubation—Three [redacted] four days

Isolation.—Twenty-one days.

Quarantine for Contacts.—Fourteen days

Method of Spread.—The secretions of the mouth and nose are infectious, even when dried So also [redacted] fæcal matter Transmission can, therefore, be by droplet

infection and possibly dust *Infected water and food* such as vegetables eaten raw, milk and ice cream may be infectious And as always in such conditions, the domestic fly is believed to be a transmitting agent It is a carrier borne disease and as mild cases occur which are not recognised and which show no signs of paralysis they are not always recognised and isolated

Prevention of Spread.—*The* prevention of overcrowding, good ventilation, careful disposal of all excreta in particular the washing of hands before eating and after defæcation and the control of fly breeding are all important measures of prophylaxis Patients must be isolated, contacts kept under surveillance and isolated on the slightest evidence of sickness Early treatment of *all cases is of the greatest importance*

Tuberculosis.

Tuberculosis is an infection caused by the **tubercle bacillus.** Chronic lesions form in various parts of the body, the patient suffers from fever and night sweats, he becomes very weak and gradually loses weight.

When the lungs are affected there is persistent cough and expectoration of pus *As* the lung tissue is des- [illegible] blood The [illegible]

When glands, bones and joints are affected, cold abscesses form and burst through the skin They are of a very chronic nature, and the wounds take a very long time to heal

There are three types of tubercle bacillus—the human type and that which is found in cattle, the bovine type and the bird or avian type

Incubation—**Unknown**

Isolation—**Persons** suffering from tuberculosis of the lungs should live under conditions of partial isolation (see p 253)

Quarantine for Contacts—Nil.

How Spread: (a) Pulmonary Tuberculosis—Pulmonary tuberculosis is spread by droplet infection and from dried

sputum The tubercle bacillus has a very tough skin which can resist drying for a long time When tubercu

Prevention of Spread.—The patient should be isolated in so far that he should have a separate sleeping room During the day, though mixing with his friends he should avoid close contact, especially when coughing He should carry a small bottle in which there is a little disinfectant, and he should spit in this. The sputum should be burned in a quick fire Unless such precautions are taken, everyone in the house will be infected Complete isolation is, of course, the ideal but this is usually quite impossible in the tropics

Rooms occupied by tuberculous patients should always be properly disinfected before occupation by others In the case of huts the simplest method is to burn them In sweeping out, the floor should be damped by sprinkling water about to prevent dust from rising The sweepings should be burnt

In certain industries, such as mining, where there is a great deal of dust in the air the lungs become irritated by the dust particles, and in this state the individual is more prone to contract tuberculosis Special arrangements are therefore made for reducing the dust as far as possible, and for frequent examination of workers so that early infection may be discovered

In some countries spitting on the ground in populous areas or in public conveyances is a punishable offence The main reason is because infected sputum when dry is dangerous

(b) Bovine Tuberculosis—Some birds, reptiles and fishes suffer from tuberculosis, but their bacilli do not infect man Cattle and pigs are also afflicted and their bacilli do infect man The infection is transmitted by the milk and butter of cattle and by uncooked meat of

This blood mixes with the plug of bacilli in the flea's gullet. The flea becomes exhausted and stops sucking, and from its distended gullet some of the blood then passes back into the host through the proboscis. The flea is thus unable to feed itself, and becomes extremely thirsty, with the result that it bites repeatedly, each time drawing blood, which it infects and then regurgitates into its host.

Prevention of Spread.—If there are no rats, there can be no plague. The extermination of rats from dwelling places is therefore the first essential in preventative measures. The methods of exterminating rats are described in Chapter IX, p. 334. The prevention of spread from patients depends on the type of the disease. Bubonic cases are not infectious in the absence of fleas unless the lungs have become involved and they are coughing and spitting. Pneumonic cases are virulently infectious, constant coughing sending out a steady spray of infected droplets.

In both cases isolation is essential, for it is never *possible to guarantee there are no fleas about, except* in a hospital ward, where special precautions are taken.

Sanitary personnel investigating suspected out breaks should wear tight fitting clothing with gum boots and rubber gloves. When pneumonic cases are suspected, a cotton-wool and gauze mask should be worn.

Protective inoculation should be provided for both attendants and contacts.

Huts and rooms should be disinfected (see Chapter VIII).

Corpses should not be carried for long distances for burial. They should be wrapped in an absorbent material thoroughly soaked with disinfectant fluid, and be buried deep on the spot.

Relapsing Fever.

...ochetes pro-
...e bites of
...ken of as
...d rat bite
...and con-

tinue for three or four days Recovery takes place, but the fever recurs after a week, with general aches and pains, sometimes once, twice or more times

Diagnosis is made by finding the spirochete in the blood This can be done by staining or by dark glass illumination under the microscope or by injecting the patient's blood into the peritoneal cavity of a white mouse

Louse-borne Relapsing Fever—Lice are prevalent only in the cool seasons in hot countries They seem to die off in hot weather The occurrence of epidemic relapsing fever is thus in a measure seasonal It occurs only among people who are habitually dirty in their habits Lice live on the body or on the clothing, and do not live apart from their hosts When they feed they suck infected blood The organisms incubate in their bodies for fourteen days, after which the lice become infective They remain infective throughout their life

Preventive measures are isolation of the infected and the destruction of lice

Tick-borne Relapsing Fever—The ticks responsible are of the genus Ornithodorus and the species varies in different countries In Africa the common vector is *O moubata* in South America it is *O talaje* Like the louse, once infected it remains infected all its life, and transmits the infection to its offspring Ticks can live for ten years if properly fed Thus when infection gets into a hut, especially in a rest camp the number of people that can be [illegible]

Rat bite Fever.—This results from the occasional bites of infected rats, ferrets and cats It can thus never become epidemic

Anthrax.

Anthrax is an infectious disease which occurs in most farm animals, such as horses goats cattle and sheep It is caused by a bacillus which forms spores The spores

can live for long periods in the ground and when brought into contact with a suitable host they develop and again become active and pathogenic In man the disease occurs in the skin as a very serious type of boil known as 'malignant pustule' which spreads and is often fatal It attacks the lung and also the food canal

Incubation—Seven to ten days

Isolation—Strict isolation during illness

Quarantine for Contacts.—Nil

How Spread—Direct contact with the spores through handling infected skins or meat The spores cling to hair and wool so that hide workers are most frequently affected by this disease

Prevention of Spread.—The patient should be isolated and infected clothing destroyed by burning or disinfected in a high pressure sterilizer

Infected animals are destroyed and burnt or buried deep in quicklime without cutting the skin because blood falling on the ground would infect and it would be difficult to eradicate the germ spores

Herds are protected by inoculation with anthrax vaccine

Tetanus

Tetanus is an acute disease caused by the toxin of the tetanus bacillus There are painful and violent contractions first of the muscles of the jaw and neck hence the common name lockjaw and later of the muscles of the body The infection enters through a wound contaminated by infected soil Soil infection is common where cattle and horses are pastured Tetanus can be avoided by careful cleansing of wounds in the skin as soon as they occur Deeper wounds must be dealt with by a doctor it is usual nowadays to protect such patients by an injection of tetanus antitoxin People peculiarly liable to wounds as soldiers in warfare are protected beforehand by inoculation with tetanus toxoid

Trachoma

Trachoma is a highly infectious disease It affects the eyes causing a destructive chronic inflammation of the conjunctiva Granulations of this membrane later cause

scar tissues to form in it which results in deformity of the eye lids and injury to the cornea

How Spread.—The disease is spread by direct contact with an infected person or indirectly by contact with articles such as towels which have been soiled by infective discharges from the eyes. Children are very susceptible and susceptibility is increased by unclean habits, poor nourishment, irritation by dust and exposure to wind and sun

Prevention of Spread.—Most important is the recognition of infection It is often overlooked or regarded as a trivial complaint Patients with granular eyelids, especially children should be treated by a doctor at once

As the infection is more liable to occur and spread [illegible] other articles

Undulant Fever (Malta Fever).

[illegible] disease is prevalent recourse may have to be had to the use of preserved milk *only* By boiling milk the germs are killed

Malaria

Malaria is a mosquito-borne protozoal disease It is characterised by bouts of fever which recur at threes or

four day intervals, the period depending on the infecting parasite Each bout of fever has a more or less characteristic course—a cold stage (rigor), a hot stage and a sweating stage There is then a one- or two day interval without symptoms Frequent attacks lead to anæmia *and great weakness*

The causes are protozoa which live in the blood cells of man and in the stomach of the female anopheline mosquito

Incubation.—About ten days

Isolation—Nil

Quarantine.—Nil

How Spread.—The disease is spread by **Anopheline mosquitoes** (see Chapter VIII, p 286) After an incubation period in the liver the malarial parasites reach the blood stream and enter the red blood cells There they grow and develop into adult parasites, taking their nourishment from the cell and destroying it. Here, too, they multiply The nucleus divides into a number of sections, each section taking a part of the parasite's body Thus a number of young parasites are formed When they have grown to a certain stage, they rupture the wall of the blood cell and escape Each young parasite enters another red cell and undergoes a similar development This is the phase of **asexual reproduction,** and if the disease be untreated it goes on and on destroying more and more red cells until the host becomes very anæmic and weak Meantime a number of parasites have acquired **sexual characteristics**—that is, some have become male others female Further development occurs in the mosquito

The signs and symptoms of the disease are related to the development of the parasite Asexual reproduction [illegible] benign tertian malaria

[illegible]

stage arrives the young parasites are established in new red cells In the quartan type of malaria the process of development is similar, but takes about seventy two hours

Prevention of Spread.—Having knowledge of the parasite and of its carrier host, the means of prevention are obvious First we can prevent the mosquito from becoming infected by treating the disease and so abolishing the parasites from the blood, secondly, we can prevent the mosquito from reaching infected blood either by protective measures or by destroying the mosquito itself

Treatment.—Quinine is specific in malaria—that is it can kill the parasite Even small doses will cause the parasite to disappear from the blood so that the mosquito cannot be infected. Small doses such as have this effect will not cure the disease larger doses taken more frequently are necessary, but this is a matter for the doctor, not for the sanitary inspector

The methods of screening dwellings against mosquitoes and of the mosquito breeding are described in Chapter VIII

Sleeping Sickness (African Trypanosomiasis)

Sleeping sickness is an insect borne disease caused by a protozoal parasite a trypanosome It affects both animals and man In man the disease runs in some parts a very prolonged course in others it is rapidly fatal In the early stages there are intermittent attacks of fever which last about a week at a time the lymphatic glands especially those of the neck become enlarged, and there is a skin rash In the late stages there is at first drowsiness later constant sleepiness and finally coma In the meantime the body wastes away and there is extreme weakness.

Incubation—This varies greatly in some cases it is [illegible]

How Spread—The disease is spread by tsetse flies (see Chapter VIII, p 315) When the fly sucks infected blood the trypanosomes multiply in the gut and the immature trypanosomes find their way into the salivary

glands From the salivary glands they pass into the human host through the biting parts of the fly

Prevention of Spread—As with malaria, preventive measures aim at (a) preventing the fly from becoming infected (b) destroying the breeding places of the fly in the neighbourhood of dwellings, roads and river fords, *so that man may not be bitten* (see pp 318 320)

Chagas' Disease.

Chagas' disease is caused by a trypanosome which is transmitted by a bug It occurs in Central and South America

Leishmaniasis

A protozoan organism called **Leishmania** is the cause of a group of diseases which occur in different parts of the world The diseases, curiously enough, in no way resemble each other

Kala-azar, which occurs in Africa, in the tropics, and on the Mediterranean coast and in other countries is *characterized by irregular fever, enlargement of the liver* and spleen, wasting and loss of strength The disease lasts for several months and has a very high mortality

Oriental sore is a very chronic ulcerative condition of the skin, chiefly affecting exposed parts It leads to much disfigurement. It is common in India and the Middle East **Espundia**, a destructive ulceration of the nose and pharynx, occurs in South America

Incubation—Unknown

Isolation—Nil

Quarantine for Contacts—Nil.

How Spread.—Sand flies are thought to be the transmitters of the infection, the genus concerned being ***Phlebotomus*** *It is a very small fly, smaller than a* mosquito It infests dusty buildings, and the females live on the blood of animals and man

Prevention of Spread—The sand fly breeds in the dust of human and animal premises Strict cleanliness in the home and the removal of cowsheds and other animal houses from the human dwelling are essential measures Nets of finer texture than the mosquito net are used for protection at night.

Filariasis.

Filariæ are slender thread like roundworms about 2 or 3 inches long The adult worms live in the lymphatics or near lymph glands of man There they may cause obstruction to the lymph flow, giving rise to swellings of the tissues The common example is elephantiasis in which enormous thickening of the skin and deeper tissues occurs These swellings are common in the legs, the eye and the scalp

Whether swellings caused by obstruction occur or not, infestation by filarial worms of any kind is spoken of as filariasis

How Spread.—The adult worms male and female, live in the lymphatic tissue of man There the female gives birth to minute worm like embryos called **microfilariæ.** They live in the blood Some are always present in the blood of the skin, some appear in the skin blood only during the day, others only during the night This is very remarkable, for those which appear in the skin blood at night are transmitted only by night biting mosquitoes while those which appear during the day are transmitted only by day biting mosquitoes When [illegible] into larvæ

The embryo on entering the stomach of the mosquito penetrates the stomach wall and finds its way into the muscles of the mosquito's chest. There it develops for two or three weeks When fully grown, it finds its way into the proboscis of the mosquito It is now in the infective stage awaiting inoculation into man When the mosquito bites the larvæ crawl down the proboscis and so enter the human host, where they grow into adult worms, male and female The female, when fertilized, produces enormous numbers of embryos, which are let loose in the blood and await a suitable mosquito to suck blood for their further development

Prevention of Spread.—This is a very difficult problem In the first place, many people have filariasis with

out knowing it Obstructive signs are not always present Infection can be diagnosed only by examination of the blood, taken either during the night or during the day, according to the nature of the filarial worm concerned Further, many types of mosquitoes transmit the infection The only way, therefore, to avoid infection is to avoid being bitten by mosquitoes Anti mosquito measures are described elsewhere

Ankylostomiasis (Hookworm Disease).

Hookworm disease is characterized by debility, bloodlessness, swelling of the lower limbs and face, wasting and mental deterioration due to anæmia In some countries this disease is very prevalent Where good food is not available, or where the people are too poor to obtain it, infection by hookworms is a very serious disease On the other hand, where food is plentiful and easy to get, large numbers of infected people are apparently little the worse for being afflicted Still, however well they may appear to be they would probably be fitter and more energetic if they were not infected

How Spread—The adult worms live in the intestine of man They produce eggs which are passed out in the fæces The eggs if deposited on suitable soil, warm and damp hatch out in a day or more The larvæ feed upon the fæces and develop After some time they mature, and cling to the damp earth or wet grass until the bare skin of man touches them They penetrate the skin immediately, and thus get into the lymphatics and the blood In the blood stream they are carried to the capillaries of the lungs There they leave the bloodvessels get into the small air sacs of the lung and find their way to the trachea, up which they climb to the mouth They then pass down the gullet to the stomach, they pass through the stomach to the upper part of the small intestine, where they attach themselves to the wall There they suck blood and produce toxic substances The female worms when fertilized pass eggs into the gut in enormous numbers and these are passed in the fæces

Prevention of Spread.—In tropical and subtropical countries where sanitary habits are lax and where the people are in the main cultivators who do not wear shoes the spread of hookworm infection is easy Spread can however be prevented in three ways (1) by sanitary disposal of fæces, (2) by avoiding contact with infected soil, (3) by treating those who carry the worms so that their fæces are not infected

The worms The egg

FIG 69 —ANKYLOSTOMA

Insanitary disposal of infected fæces leads to contamination of the ground, infection of water and of vegetable foods and fruits which are eaten uncooked The methods of fæces disposal are described elsewhere

The avoidance of contact with infected soil cannot be accomplished by people who work on the soil Even though the feet are protected the hands and arms must be exposed

By mass treatment much can be done but even this method must be ineffectual without the obervance of sanitary habits for 100 per cent of cures can never be guaranteed Thus the only way to keep the disease under is by educating the people at large in sanitary habits and at the same time treating those affected

Schistosomiasis.

Schistosomes are flatworms They are parasitic on man and live in the large veins of the portal system They cause three main types of disease

(a) Urinary schistosomiasis
(b) Rectal schistosomiasis
(c) Dropsical schistosomiasis

The urinary type is characterized by inflammation of the bladder and the passage of blood in the urine, the

How Spread—The adult worms male and female, live in the portal vein The female lays her eggs in enormous numbers in the venous blood stream, and by some means the eggs find their way to the bladder and rectum They penetrate the walls of these organs and pass out in the urine or fæces If the fæces are deposited on dry ground, the eggs soon die, but if they reach water, they hatch out almost immediately, and small ciliated embryos are released These embryos are called **miracidia (S miracidium)**, they are microscopic They swim about in the water searching for the intermediate host a certain type of snail If no snail be found, they die in about a day, but if they meet a

SCHISTOSOMA (BILHARZIA) LIFE HISTORY

FIG 70—THE EGGS

FIG 71—THE CILIATED EMBRYO

FIG 72—TYPES OF SNAILS IN WHICH THE EMBRYOS DEVELOP

FIG 73—THE CERCARIA WHICH ENTERS THE SKIN OF MAN

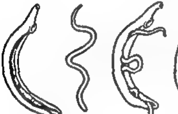

FIG 74—THE ADULT WORMS (MALE AND FEMALE)

FIG 75—THE SITES OF THE DISEASE

suitable snail they bore into it and find their way to the liver where they undergo a complete change The body becomes hollow-shaped and on the inside small buds appear which produce cercariæ (larvæ) After some weeks these larvæ are fully grown and make their way out of the snail's body into the water where they can survive for one or two days At this stage of development they are only just visible to the naked eye They are now infectious and if they come into contact with the skin or mucous membrane of their warm blooded host they penetrate at once and find their way through the tissues to the portal vein where they develop into adult worms When mature they copulate and the female begins the life cycle again by producing vast numbers of eggs

Prevention of Spread—The only practicable methods of prevention are to attack the worm itself in its host by curative medicines and at the same time to educate the population in sanitary measures which will ensure a break in the life cycle of the worm

Where the disease is prevalent, the population must be attacked in mass All sufferers are treated by intra venous injections of a preparation of antimony, which kills the eggs and also the parasites But as it is never possible to guarantee a 100 per cent of cures, the import ance of teaching people how the life cycle can be broken by sanitary habits must not be neglected A knowledge of the life cycle makes obvious the methods by which it can be broken

Guineaworm

The guineaworm infests the subcutaneous tissues of the legs The female worm discharges its embryos through a small puncture in the skin Inflammation of the cellular tissues frequently results from infective organisms getting in through the puncture

How Spread—The female worm lies under the skin usually of the lower part of the leg *It is a long worm* about 20 to 30 inches in length and 1/10 inch in thick ness When impregnated, the female uterus, which is very large, becomes distended with embryos The head

GUINEAWORM LIFE HISTORY

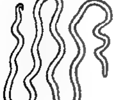

FIG 76 —THE FEMALE GUINEAWORM

FIG 7 —THE EMBRYO OF THE GUINEAWORM

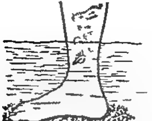

FIG. 78.—THE GUINEAWORM DISCHARGING ITS EMBRYOS

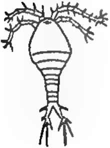

FIG. 79.—THE CYCLOPS

FIG. 80.—MAN AFFECTED BY DRINKING WATER CONTAINING INFECTED CYCLOPS

through which the embryos are born burrows down towards the ankle it protrudes and the embryos are discharged If these reach water they swim about looking for their intermediate host a water creature called cyclops In the body of this minute creature the embryos develop and man is infected by drinking the water containing the infected cyclop The body of the cyclops is digested and the young worms are thus let loose They penetrate the stomach wander about the body and usually settle in the subcutaneous tissue of the leg

Prevention of Spread.—Where there is liability to infection, drinking water should be filtered The cyclops is thus removed Patients should refrain from allowing the discharges from the leg wound to contaminate open water

Tapeworms.

Tapeworms are of two main types—the pig type, *Tænia solium* and the cow type, *Tænia saginata* They are long flat, segmented worms which live in the gut, usually causing no symptoms, but liable to cause colicky pains, irregularity of the bowels, sometimes a voracious appetite and other symptoms

How Spread—The worm attaches itself to the bowel wall *by means of suckers or hooklets on the head*, which is no larger than a pin head From behind this minute head the segments develop and grow, the total length of the worm reaching 4 to 6 yards These worms are hermaphrodite, the male and female organs being present in the same body

As the segments grow, ovaries and testes, the female and male organs, develop When the ova become fertilized, the uterus then begins to grow As it grows the ovaries and testes disappear, and the uterus, which is distended with eggs, occupies the entire segment The mature segments break off and are passed in the fæces

Further development of the eggs depends on whether they are eaten by their intermediate hosts or not In the case of *T saginata* it must be eaten by a cow, *T. solium* must be eaten by a pig but in this case man may also be the intermediate host

In the stomach of the host the eggs hatch out, the embryos leave the stomach, pass into the capillaries and are carried to the muscles, where they develop into small cysts These cysts contain fluid and the head of the future worm They are visible to the naked eye as small greyish translucent bodies dotted about in the muscle tissue Such meat, spoken of as "measly" meat, when eaten raw or undercooked will infect man, the

The Tapeworm Life History

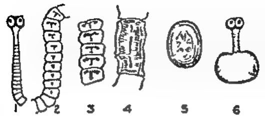

Fig 81 —The Tapeworm

1 The head, about the size of a large pin
2 Growing segments
3 Immature segments
4 Mature segment, showing the uterus full of eggs and the opening through which the eggs pass
5 The egg (much enlarged) is passed on the ground and is eaten by the cow. In the cow it develops and grows into—
6 A cyst, which can be seen in infected meat. It is a little less than $\frac{1}{2}$ inch long. In man the cyst wall is digested and the young worm attaches itself to the lining of the gut where it grows.

The tapeworm of pig meat has a similar naked eye appearance and a similar life history.

Fig 82

Fig 83

Fig 84

definite host *The bladder like wall of the cyst* is digested and the head attaches itself to the intestinal wall

In the case of *T solium*, man may become infected by the egg and act as the intermediate host The presence of cysts in the muscles give rise to muscular pain, and if the cyst occurs in the brain he may suffer from fits resembling epilepsy

Prevention of Spread.—In tropical Africa few natives can afford to condemn and discard measly meat They can, however, render it safe by thorough cooking Sanitary inspectors must of course, condemn and destroy measly meat People who are infected should be treated and should observe such sanitary habits as will prevent the intermediate hosts from reaching the eggs

A B

FIG 85 —ROUNDWORM
A Ascaris adult worm about 1 foot long, B egg (microscopic)

The Roundworm (*ascaris lumbricoides*)

The round worm is cylindrical, pointed at both ends of a pinkish colour and about 12 or more inches in length It is parasitic on man, and there is no intermediate host It causes itching of the nose, nausea and abdominal pain, and more serious conditions such as intestinal obstruction and fits

How Spread—The female, when mature, contains many millions of eggs, which are passed in the fæces The eggs have a hard shell which enables them to resist drying Infected fæces when dry, are blown about

Thus water and food are liable to become *infected.* When eaten by man the eggshell is digested and the larvae are set free They pass from the stomach to the liver and from there by the blood stream to the heart and lungs They enter the air sacs travel up the trachea and are swallowed a second time after which they develop into adult worms

Prevention of Spread—The sanitary disposal of faeces and personal cleanliness especially care of the hands and finger nails will prevent infection and reinfection

CHAPTER VIII

MEDICAL ENTOMOLOGY

Medical entomology concerns itself with the study of insects and other arthropods such as ticks and mites and in particular of those kinds which cause diseases in man In tropical countries the largest group of illnesses are probably insect borne and it is important to know the habits of the insect vectors and how they transmit disease

An insect has a head thorax and abdomen three pairs of legs and usually one pair of wings, though some have two pairs and others none Instead of bones they have a sort of external skeleton or hard skin called chitin Ticks and mites are unlike insects because they are not divided into three parts there is no such division and they have four pairs of legs instead of three

Insects breathe through a network of tubes which are found throughout the body and open at various places on the skin. They have nerves and colourless blood and possess well developed alimentary and reproductive systems

Most insects pass through complicated stages whilst growing from egg to adult A female insect is fertilised by the male it then lays eggs which hatch into larvae The larva grows in size and eventually becomes an adult sometimes it passes through a pupal stage before finally

becoming mature. Very often the larva looks totally different from the adult, as for instance in mosquitoes. When the young stages resemble the adult the forms are called nymphs instead of larvæ

Insects are delicate creatures and are very susceptible to the environment Most of them do best in the warm moist climate of the tropics In colder places, they take longer to reach maturity, in drier places the death rate from desiccation is high Many insects fluctuate in number according to the season—usually they are most numerous after the rains but a few kinds, like ticks for instance, are found in largest numbers in the dry season

Insects are of great importance because many of them are the natural carriers of human diseases The parasites of these diseases have one home in the human body and a second home in the insect and in order for the vigour of the parasite to be maintained, it has to have frequent changes from one host to the other

Climate affects the development of the disease in the

of the germ in the body of the insect

Insects are dangerous to man in other ways also The

cause profound shock Everyone is familiar with the general annoyance resulting from insect bites and this tends to lower resistance to disease. Because of their habits, insects are liable to transfer, mechanically, germs from a contaminated source to food or drink and thus cause epidemics of disease For instance, flies may feed on the excreta of a typhoid patient and then crawl over food destined for human consumption Whilst the flies crawl over the food, the typhoid germs get deposited on *it and when a person eats this food, he may get infected*

Insects are also harmful to man because they transmit various diseases to his domestic stock and this may

cause such a loss that he has to move [redacted] another place where the disease or the insect [redacted] absent

The following table gives a list of the more important insects and the human diseases they carry

HUMAN DISEASES CAUSED BY ARTHROPODS

Name of Arthropod		*Disease Caused*
Bed bug	*Cimex*	None*
Reduviid bug	*Triatoma*	S American trypanosomiasis
Cockroach	*Blatta etc*	None*
Louse	*Pediculus*	Relapsing Fever Typhus
Mosquito	*Anopheles*	Malaria
„	*Aëdes*	Yellow Fever Dengue
„	*Culex*	Filariasis
Buffalo gnat	*Simulium*	Onchocerciasis
Mangrove fly	*Chrysops*	Loa loa
House fly	*Musca*	Typhoid dysentery, etc
Sandfly	*Phlebotomus*	Leishmaniasis, Bartonellosis, Sandfly fever
Tsetse fly	*Glossina*	Sleeping sickness
Non biting flies	*Auchmeromyia* *Dermatobium, etc*	Myiasis
Flea	*Xenopsylla, etc*	Plague, Murine Typhus
Chigger flea	*Tunga*	Chigger disease
Tick	*Ornithodorus*	Relapsing fever
„	*Rhipicephalus*	Typhus
Mite	*Trombicula*	Typhus
„	*Sarcoptes*	Scabies

* The bed bug and the cockroach have been suspected of acting [redacted] the vectors of various diseases but definite proof is lacking

Short descriptions of these insects are given below and also some of the methods used in their control or eradication Insects occur in many different forms or species each of which possesses its own special problem The descriptions, therefore *are only examples and* it is essential that these should be elaborated by the tutor as local circumstances demand

BEDBUGS

Identification—Bedbugs are rather small wingless insects rounded in outline and much flattened from above downwards (see Fig 86) This flattening will distinguish them from all other insects with which they could be confused Their colour is dark reddish brown They have a very distinct unpleasant smell and in a house or room which is heavily infested by them he smell will often betray their presence

Life History and Habits.—The eggs are laid in cracks and crevices of walls and furniture especially in the framework of beds The female lays batches of two to six eggs usually at intervals of twenty four hours and the eggs hatch in from four to eight days

The young bugs are very similar to the adult and are therefore known as nymphs and not as larvæ There are four nymphal stages before the bug becomes adult and at the end of each stage the nymph casts its skin which has become too small for it The period from *hatching from the egg* to the bug becoming adult is nearly five weeks The habits and food of the nymphs are the same as those of the adults

Bugs thrive particularly in dirty houses and hide by day in the cracks and crevices of walls and furniture They come out at night to suck blood which *is their only food*

They deposit their fæces as little black spots around [illegible]

Diseases Transmitted.—Bedbugs [illegible] to carry disease but are a source of annoyance and loss

[ ]r sleep and thus weaken people and make them more [lik]ely to get other diseases

Remember that any insect that sucks the blood of [ma]n is a potential source of danger and disease

[C]ontrol.—1 Search all crevices and cracks in the walls [and] kill all bugs found. Place all beds and bedding and

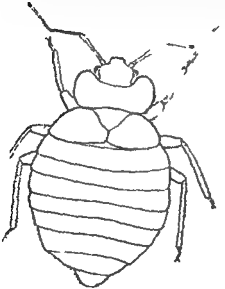

Fig 86 —A Bed Bug

all other furniture in the sun and search carefully for bugs in these Bugs in cracks and crevices can be killed by pouring boiling water into the cracks or by dipping a feather in kerosene and pushing it into the cracks

Repeat the above every day for at least ten days [illegible] as to kill young bugs which have hatched in the mean time and any which have not been touched by the kerosene or boiling water

A D D T oil spray (see page 329) [illegible] extremely lethal to bed bugs and the effect lasts for about six months *Beds and furniture should be treated also the walls* and the ceiling or roof The insects die as the result of contact with the deposit of D D T on furniture etc so [illegible] is unnecessary to spray them directly They may take a day or so [illegible] die

3 Once the house is clear of bugs it is important to keep [illegible] free of them Keep the house as clean as possible and search frequently for bugs Put all beds and bedding out in the sun for a few hours once every week

REDUVIID BUGS

Identification—These insects are also known as assassin or kissing bugs They are larger than bed bugs and they possess wings The abdomen [illegible] long and is not flattened (Fig 87 p 279)

Life History and Habits—There are many different kinds of these bugs some of which inhabit thatched adobe huts of man lurking in the cracks and crevices and others the burrows of wild animals such as arma dillos bats and field rats Their life history is like the bed-bug s and they are avid blood suckers They par ticularly attack the uncovered face of a person asleep biting the lips—that is why they are called kissing bugs

Diseases transmitted.—Chagas' Disease, or South American T[illegible]
with a gern[illegible]
reduviid bu[illegible]
tant reservo[illegible]
animal or man the trypanosomes develop in the gut, eventually becoming numerous in the fæces and [illegible] through a bite or scratch becoming contaminated with the bug[illegible] fæces that infection results

Method of Control.—Complete control is difficult because of the widespread distribution of these bugs in outside haunts, but the use of bed nets at night will prevent them biting and the treatment of the walls and floors of a building with a 5 per cent. spray of DDT in kerosene will eradicate the insect from houses

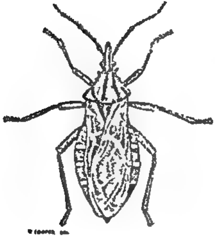

Fig. 87.—A Reduviid Bug.
The transmitter of Chagas' disease

COCKROACHES

Identification.—Cockroaches are large reddish brown insects rather flattened from above downwards but not so much as the bedbugs They will easily be identified from the figure (Fig 88). The adults have wings but these are folded closely to the back and will not be noticed unless carefully looked for

Both adults and nymphs feed only by sucking man s blood and all species of lice die quite soon if they are unable to obtain blood

Diseases Transmitted.—The principal disease carried by lice is typhus (not to be confused with typhoid, which is an entirely different disease and is not carried by lice)

89

FIG 89 —A BODY LOUSE (*Pediculus humanus*)
(Wenyon s *Protozoology*)

Typhus is carried either by an infected louse biting a healthy person or by his crushing a louse and some of its infective juices getting into a wound (such as a louse bite) or by scratching a louse bite and getting the infected fæces of the louse into the wound thus caused Lice also transmit the epidemic form of relapsing fever which can spread very rapidly and cause thousands of deaths This dease is not transmitted by the bite of the louse but through crushing the insect when the escaping germs get into a scratch or abrasion of the skin of the person The germs take about a fortnight to develop in the louse

Control.—1 Clothes (including bed-clothes) should be washed and ironed at least once a week The heat of the iron kills all stages of lice including the eggs

2 The clothes which have been worn during the day should not be worn to sleep in and it is a good plan for a person with two suits of clothes to wear them on alternate days

3 Hot baths should be taken as often as possible

4 Lice are very susceptible to D D T and a person can easily get rid of them by using D D T powder In the same way threatened epidemics of the louse-borne disease

can be prevented by using D D T on a large scale The best way of applying the powder is to rub it into all hairy parts of the body and head, and into all articles of clothing which should be turned inside out Blankets should also be treated The powder is applied from tins with perforated lids and about 2 ounces per person is required. If D.D.T is not available, infested clothes

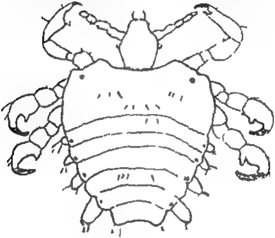

FIG. 90.—A Crab Louse (*Phthirus pubis*)

can be completely freed from lice by boiling in water At the same time, it is necessary to have a hot bath using plenty of soap, so as to get rid of any lice remaining on the body.

MOSQUITOES

Identification.—Mosquitoes are slender bodied two winged flies They can be distinguished from other kinds of two-winged flies with slender bodies by their long projecting proboscis, which is a small tube containing

the mouth parts. Mosquitoes are divided into two main groups—Anophelinæ and Culicinæ. The difference between the two groups will be given below.

Life History and Habits.—All mosquitoes go through four stages of life history—egg, larva, pupa and adult.

The eggs are laid either on water or in places where they will be washed into water by rain. They hatch to produce larvæ.

Mosquito larvæ are small grubs or "wrigglers" which live in water. They feed on tiny particles of food in the water and after a time which is very variable according to climate and the species of the mosquito they change to pupæ. They must (in nearly all species) come to the top of the water to breathe.

Mosquito pupæ are comma-shaped and, like the larvæ, live in water. They are a resting-stage during which the adult is developing; for this reason they do not feed, but they can swim by flapping their tails. Nearly all species must come to the surface of the water to breathe. The pupa period is usually only about two days and at the end of this time the pupa comes to the top of the water, its skin splits and the adult mosquito climbs out of the skin and flies away.

Adult mosquitoes vary a good deal in habits, but the important species are those which feed on human blood. In these species only the female sucks blood, the male has less developed mouth parts and cannot bite. The female requires blood because without it her eggs will not mature. But she can live for long periods by sucking the juices of fruits and plants, and these are the only food of the male.

Most adult mosquitoes hide by day and come out at night to feed (that is to say, they are nocturnal). But there are others which feed by day and rest at night, (they are diurnal). The nocturnal species hide by day in dark places, sometimes among grass, but the most dangerous species in dark corners of houses.

Diseases Transmitted.—The principle diseases carried by mosquitoes are malaria, yellow fever, dengue and elephantiasis or filariasis.

1 Malaria is carried by certain species of Anopheline mosquitoes (see p 287) After sucking the blood of a man suffering from malaria, the mosquito then hides in a dark corner of the dwelling to digest the blood she has sucked, and to await the development of the eggs in her body When she sucked in the infected man's blood she sucked in the malaria parasites as well The blood is digested in a few days but the malaria parasites have not been digested they have undergone a change in the meantime They have become what we call oöcysts on the walls of the stomach and look like small lumps These oöcysts burst and small worm like things called sporozoites work their way into the salivary glands so that when the mosquito next bites a person the sporozoites pass through the proboscis into the blood of the person on whom the mosquito is feeding This happens because when the mosquito bites it injects fluid from the salivary glands to prevent the blood clotting and clogging the proboscis, the sporozoites are injected together with the salivary fluid It is this fluid which causes the irritation and lump which result from a mosquito bite

The cycle in the mosquito lasts about a fortnight that is from the time it sucks in the infective blood until it contains ripe sporozoites in the saliva The sporozoites develop in the body of the person who has been bitten First of all they enter liver cells where they grow into large bodies which eventually produce a thousand germs These germs escape into the blood and give rise to an attack of fever About 10 days to a fortnight elapses from the time the mosquito bites until the onset of fever

2 Yellow Fever.—This disease is carried by certain Culicine mosquitoes (see p 292), and especially by *Aëdes aegypti* (see p 293) The very tiny organism of yellow fever, known as a virus is present in the blood of a person suffering from this disease during the first three days of his illness, and is sucked in with his blood by any mosquito which bites him After this it is necessary for the virus to develop in the mosquito for about twelve days before it can be passed on and in many kinds of

mosquitoes this development cannot take place and the mosquito cannot pass on the disease But if the mosquito is of the right species the virus is ready to be passed on at the end of the twelve days, and after this any person who is bitten by the infected mosquito is liable to get the disease

Important reservoirs of yellow fever are the monkeys of the African and South American forests Special species of mosquitoes (*Aedes africanus* in Africa and Haemogogus in South America) carry the disease from monkey to monkey high up in the forest canopy and it is only rarely that one of these mosquitoes bites man Sometimes, an infected monkey raids a plantation near the forest and is bitten by another common mosquito *Aëdes simpsoni* which subsequently transmits the disease to man

So there are three forms of yellow fever, (1) the urban epidemic carried by *A aegypti* (2) Jungle yellow fever carried by special forest mosquitoes and (3) rural yellow fever carried by *A simpsoni* etc, in Africa and by *A aegypti* in S America

3 **Dengue** is another virus disease transmitted by *Aëdes aegypti and other mosquitoes but unlike yellow* fever it is not a fatal disease It usually occurs in abrupt epidemics There is no known animal reservoir

4 **Elephantiasis or Filariasis** is transmitted by many different kinds of mosquitoes of which the most important is *Culex fatigans*

The cause of the disease is a worm known as a Filaria the larvæ of this worm lives in man's blood and are sucked up in the blood when he is bitten by a mosquito In many mosquitoes the worm is digested by the mosquito and does not develop, but in other species the larvæ develop for a short time and then get into the proboscis of the mosquito, where they are ready to enter the blood of the next person whom the mosquito bites and they infect him with the disease

Anophelines

Identification—Adult Anophelines can be distinguished from other mosquitoes by the following points

1 They almost always have spotted wings

2. When sitting on a wall, the adult Anopheline has the three parts of its body (head, thorax and abdomen) all in one straight line Culicines sit with the head and abdomen lowered towards the wall and the thorax (the middle portion) humped up (see Fig 91)

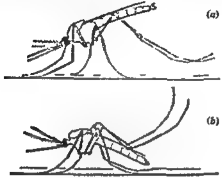

FIG. 91—RESTING POSITIONS OF (a) ANOPHELINE (b) CULICINE MOSQUITOES
(Wenyon's Protozoology)

alled the

opheline

at the surface of the water, Anopheline larvæ lie just under the surface and parallel to it, so that the whole of their upper surface is practically touching the surface of the water (Fig 92) Culicine larvæ lie with only the syphon touching the surface of the water and the rest of the body hanging down at an angle (Fig

face touching the surface of the water

mosquitoes this development cannot take place and the mosquito cannot pass on the disease But if the mosquito is of the right species the virus is ready to be passed on at the end of the twelve days and after this any person who is bitten by the infected mosquito is liable to get the disease

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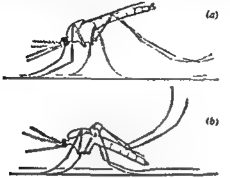


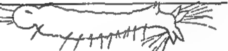
FIG 91—RESTING POSITIONS OF (a) ANOPHELINE (b) CULICINE MOSQUITOES
(Wenyon's Protozoology)

[illegible]

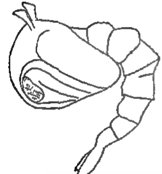
examination will show that they are really hanging from the syphon and not lying with their whole upper surface touching the surface of the water

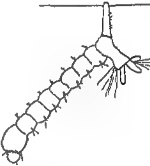
The difference between the eggs and pupæ of the Ano phelines and Culicines are not of importance to students But it is worth remembering that the eggs of Anophelines

Egg raft (Culicine)



Larva (Anopheline)





Pupa (Anophel ne) Larva (Culicine)

Fig 92 —Life History of a Mosquito

and some species of Culicines are laid singly, and hat rafts of eggs (Fig 92) always belong to Culicines

There are very many different species of Anophelines some of which do not carry malaria The differences between them can only be learnt by practice

Important Anopheline vectors of malaria are shown in the Table on p. 290. All the commonest species are mainly nocturnal.

Life History and Habits.—The life history is the same as for all species of mosquitoes, i.e. egg, larvæ, pupæ and adult. The whole life history from the laying of the egg to the hatching of the adult usually lasts a little over a week, but this period may be shortened to five days in the hottest places, whilst in colder climates, it may last for a month or more. Adult mosquitoes probably live for about a month in the Tropics.

The early stages of the vector species breed in many different types of water (see last column in the table on p. 290) and there is a wide variation in their habits. Three examples from different parts of the world are given below.

A. gambiae is the most dangerous species in Africa. The adults spend most of their time in houses and they prefer human to other kinds of blood. They like darkness and they prefer houses that are cool by day and warm at night—such as mud and wattle or grass huts. They are much less numerous in well lit stone houses or in huts of wood and iron. During the daytime they rest on the upper parts of the walls, on the inside of the roof, and under the eaves. *A. gambiae* is most active between 11 p.m. and 5 a.m. It is occasionally found out of doors, in long grass, under culverts and sometimes in very large numbers in the forest. It can fly for several miles.

The larvæ are particularly abundant during the rains, because their favourite breeding sites are small temporary pools of fresh water exposed to sunlight. They are found particularly in the hoof marks of cattle and hippopotami, in pools in borrow-pits, wheel tracks in muddy ground, drains and excavations—in other words, in breeding places which as a whole have largely been created by man. The breeding places often have no vegetation growing in them because the larvæ prefer sunny places; when there is grass in the pool, larvæ will be found in more open parts. A special variety of

The d [illegible]

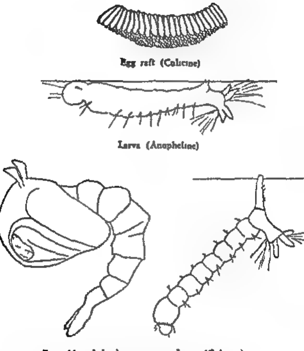


FIG 92.—LIFE HISTORY OF A MOSQUITO

and some species of Culicines are laid singly, and that rafts of eggs (Fig 92) always belong to Culicines

There are very many different species of Anophelines, some of which do not carry malaria The differences between them can only be learnt by practice

Important Anopheline vectors of malaria are shown in the Table on p 290 All the commonest species are mainly nocturnal

Life History and Habits —The life history is the same ■ for all species of mosquitoes i e egg larvæ pupæ and adult. The whole life history from the laying of the egg to the hatching of the adult usually lasts a little over a week but this period may be shortened to five days in the hottest places whilst in colder climates it may last for a month or more Adult mosquitoes probably live for about a month in the Tropics

The early stages of the vector species breed in many different types of water (see last column in the table on p 290) and there is a wide variation in their habits Three examples from different parts of the world are given below

A gambiae is the most dangerous species in Africa The adults spend most of their time in houses and they prefer human to other kinds of blood They like darkness and they prefer houses that are cool by day and warm at night—such as mud and wattle or grass huts They are much less numerous in well lit stone houses or in huts of wood and iron During the daytime they rest on the upper parts of the walls on the inside of the roof and under the eaves *A gambiae* is most active between 11 p m and 5 a m It is occasionally found out of doors in long grass under culverts and sometimes in very large numbers in the forest. It can fly for several miles

The larvæ are particularly abundant during the rains because their favourite breeding sites are small temporary pools of fresh water exposed to sunlight. They are found particularly in the hoof marks of cattle and hippopotami in pools in borrow pits wheel tracks in muddy ground drains and excavations—in other words in breeding places which as a whole have largely been created by man The breeding places often have no vegetation growing in them because the larvæ prefer sunny places when there is grass in the pool larvæ will be found in more open parts A special variety of

A. gambiae—var *melas* breeds in the salt water of mangrove swamps in West Africa

A garobiae is the species of mosquito which crossed the Atlantic to establish itself in Brazil and which travelled down the Nile to cause disastrous epidemics of malaria in Upper Egypt.

Important Anopheline vectors of malaria

Region	*Species*	*Breeding Places*
Europe	*Maculipennis*	Swamp, sunny
	Superpictus	Stream, sunny
North Africa and Middle East	*Sergenti*	
	Stephensi	Swamp, wells
India	*Culicifacies*	Pools in streams shady
	Minimus	Streams, sunny
	Fluviatilis	Streams, sunny
South East Asia	*Sundaicus*	Brackish swamp sunny
	Maculatus	Streams, sunny
	Umbrosus	Swamps, shady
	Hyrcanus	Rice fields, sunny
	Aconitus	Pond, grassy
Australasia	*Punctulatus*	Pools sunny
Africa	*Gambiae*	Pools, sunny
	Fenestus	Streams, grassy
North America	*Quadrimaculatus*	Swamps, grassy
South and Central America and West Indies	*Albimanus*	Pools, sunny
	Bellator	Base of tree plants
	Pseudopunctipennis	Pools, sunny
	Darlingi	Swamps, grassy
	Aquasalis	Pools, sunny

There is some overlapping of species in the different regions, thus *A stephensi* occurs in India as well as in the Middle East, etc

A minimus is a potent and wide-spread carrier in the Oriental Region. Its main day time rest ng places are dark native houses and coolie huts where most of the mosquitoes are found hanging from the underside of the bamboo beds The great majority are found in the lower half of the room Most of the mosquitoes leave the house at sundown they do not return until after mid night, and it is then and until dawn that they particularly bite man In some countries this mosquito shelters in ravines and nullahs during the day It is a strong flier and can travel well over half a mile

The larvæ are found especially in slow running streams with grassy edges and are most numerous during the warm weather Other breed ng places are the edges of swamps in irrigation canals rice fields and in seepages The larvæ like a certain degree of shade and have a preference for the cooler water The chief breeding place of this species is in permanent water

A bellator is an important vector of malaria in the West Indies The adults attack man viciously and often in swarms They bite throughout the afternoon especi ally on dark days in the greatest numbers between 6 and 7 p m Feeding takes place chiefly out of doors in the shade of the forest if they feed indoors they leave almost immediately after their meal and return to their jungle resting places Man is commonly attacked whilst working in the cocoa drying sheds or in similar sheds without walls These mosquitoes are much less active in the early morning and during hot dry spells of weather

The larvæ are found in one kind of breeding place only —and a most curious one This is the bromeliad plant, or wild Pine which grows on the trunks and branches of trees—particularly the immortelle tree which is used for shade in the coco plantations The larvæ are found in the water collected at the base of these plants the broad leaves of which can sometimes hold as much as a bucketful of water

The habits of these three species (*A gambiæ min mus* and *bellator*) are very different, and this difference shows how necessary it is to find out all about the local vec

Breeding Places and Habits.—*A aegypti* and its near relatives do not breed in swamps, pools or ditches like Anophelines do It prefers small breeding places (usually, but not always, near houses), such as barrels, water pots, roof gutters, closed water tanks, discarded tins or bottles, or almost any small thing capable of holding water—even such things as discarded tyres of motor cars It also breeds commonly in holes in trees and sometimes

is commonly found there has a larva almost the same as that of *A aegypti*, and is often mistaken for it. This is *Aedes simpsoni*

A aegypti and its nearest relatives are all diurnal—that is to say, they fly about and bite by day *A aegypti*

Mosquito Surveys.

Mosquito surveys are carried out to find out what are the dangerous species of mosquitoes in the place concerned, and where these dangerous species are breeding. Two different surveys are therefore needed an adult survey and a larva survey

Adult Surveys.

The adult survey is done to find out what dangerous species of mosquito occur in the house in that particular place

Apparatus Required.

1 A map of the town or other area.
2 Pencil and paper (or notebook).
3 An electric torch.

4 A number of test tubes and some cotton wool. Before leaving the office or laboratory a paper label should be gummed on to each test tube

5 A haversack in which these things can be carried, so as to leave both hands free

Method of Work.—1 On arrival at a house which is going to be searched for mosquitoes, mark its position on the map and give it a number Mark this number on the map

2 Search inside the house for mosquitoes, paying particular attention to dark corners, curtains, or clothes hanging up In well lighted houses of European type most mosquitoes will be found in any dark rooms (bath room, latrine, or servants' quarters) In grass roofed huts mosquitoes will be found to be sitting on the inside of the roof or on the roof beams, as well as in other places The torch is used to enable mosquitoes to be seen

3 When a mosquito is seen, carefully place the mouth of one of the test tubes over it and then move the test tube slightly so as to disturb the mosquito, which will fly up into the tube Then plug the mouth of the tube with a piece of cotton wool and push this down so as to drive the mosquito into the end of the tube, but not so far as to crush the mosquito Treat other [illegible]

suction tube can be employed The open end is placed near the resting mosquito, suction is applied and the mosquito is drawn into the tube In this way large numbers can be collected in a few minutes

4 Label the tube with the number of the house (the same number as was written on the map) and the date If several tubes have been used, write the same number on *all tubes from one house*

5 Write in the notebook the number of the house, its position, and a short description of the house particularly whether it is of European type, a thatched hut, or some other type, and whether it is clean

the breeding place is very small (such as a hoofprint), use the ladle instead of the dish Any pupæ found should be collected as well as larvæ

4 Dip the dish among plants growing in the water and also in other places where larvæ may be hiding When no more larvæ are obtained, stir up the mud at the bottom, wait a few moments and dip again This will often bring up to the surface larvæ which were hiding at the bottom When examining the dish to see if any larvæ have been caught, do not forget that most larvæ go to the bottom when disturbed Place the dish on the ground and wait a short time to allow larvæ to come to the surface again

5 Write the number of the breeding place and the date on the label of the test tube and plug it with cotton wool

6 Make a written note as to whether larvæ were found or not whether they were Anophelines or Culicines, whether they were among plants or in the open water and the approximate number of larvæ found

7 Go on to search for the next breeding place Never put larvæ from more than one breeding place in the same tube

Special Methods—Several types of breeding place require special methods of searching, and the following are examples

1 Some larvæ, especially those of *Anopheles funestus*, are specially wary, and cling to plants under water or even wriggle out on to the mud when they are disturbed. Approach the breeding places very cautiously and so as not to throw a shadow on the water Then stoop down and make a quick downward stroke with the dish (held at an angle of about 30 degrees) amongst the plants just below the surface of the water

If the breeding place is a large one, the large basin should be used next Let the basin float on the surface of the water for a few seconds then hold the brim with both hands (one on each side of the basin) and press the basin suddenly under the water The rush of water into the basin will often bring into it larvæ which were clinging to the plants

, These methods should be repeated several times

2 Small breeding places Tins, bottles etc are emptied into the dish Barrels and large tree holes are searched by means of the dish, and gutters and smaller tree holes by means of the ladle The larvæ which are found in such places get much of their food on the sides and bottom of the breeding places so a careful search is necessary before deciding that no larvæ are present. For very small tree holes and for plant axils a glass tube 18 inches long and ¼ inch in diameter is attached to 3 feet of rubber tubing The glass tube is pushed down to the bottom of the hole and the water sucked into it, then the end of the rubber tube is held over the dish (placed well below the level of the tree hole) and the water will run into the dish bringing the larvæ with it.

3 Larvæ which do not come to the surface to breathe Larvæ of *Mansonia*, which do not come to the surface to breathe, are not caught by ordinary methods If a dish is used it is necessary to push it hard against the under water plants so as to shake off the larvæ clinging to them A better method is to use a net and sweep it about among the plants under water then wash the inside of the net into the dish or basin

4 Many mosquitoes breed in well water and in order to collect the larvæ, it is necessary to use a weighted cone-shaped net which is let down from a rope into the middle of the water It is allowed to remain stationary for a time, then moved around particularly by the edges and finally pulled up The larvæ are then washed into a basin from the net.

5 The special methods for detecting *Aedes* larvæ are described under yellow fever control (p 306)

No one can be a successful larva collector unless he is prepared to get wet. It is no good trying to keep one's feet dry and at times it is necessary to go into the water up to the waist Rubber boots or waders are useful in some places particularly if there is a risk of schistosomiasis

5 A pyrethrum spray (see page 328) should be used twice a day Special attention should be given to dark corners, behind curtains, under beds and baths, and the spray should also be directed upwards to the corners of the ceiling

6 In some circumstances, it is necessary to apply a mosquito repellent. Dimethyl phthalate is by far the best one and small quantities should be dabbed on all exposed parts of the body, though it is unnecessary to cover every inch of skin It acts like a magic shield and gives complete protection for three hours Creams containing the substance protect for even longer

7 Finally, there is the best method of all, for most places—the treatment of houses with D D T or "gammexane" This is a method which has to be carried out by the public authority to be really satisfactory, because unless *every* house is treated, the method loses a lot of value, mosquitoes soon re-establishing themselves The choice of insecticides and the methods of application depend upon local conditions The more important sprays are described on page 329 The general principle is to deposit a film of insecticide on all surfaces upon which mosquitoes may alight, it is *not* to spray and kill the actual insects themselves and therefore the usual flit spray which provides a fine mist is unsuitable A larger type such as a stirrup pump or a Kent Sprayer with a nozzle giving a fairly coarse spray is required. The object is to deposit approximately 200 mgm of D D T on to each square foot of surface Circular huts of 20 feet or so in diameter require nearly a gallon of a 5 per cent. solution The actual dosage depends upon the type of construction of the house a wooden house needing less a mud and wattle more D D T This deposit is lethal for mosquitoes for three or four months and in many places it is only necessary to spray two or three times in the year

It now seems possible that the systematic use of D D T or "gammexane" will exterminate certain species of mosquitoes over very wide areas of land whole islands whole countries and perhaps one day over whole continents

B Control of Mosquito Larvæ

The control of larvæ of Anophelines and of many species of Culicines needs either drainage work, or applications on a large scale of substances which kill larvæ Such work cannot be carried out by the ordinary person and will usually be done by the public authority But students may be employed in connection with such work, and ought therefore to understand a little of what is being done and why it is done

Remember that many of the important malaria carrying mosquitoes are found in man made breeding places and that the yellow fever mosquito likes domestic utensils as much as anything in which to breed. So with some care it is possible to prevent quite a lot of mosquitoes from appearing at all. Prevention is better and much cheaper than cure

The following are the chief ways of avoiding the creation of breeding places —

Borrow pits should be so dug that they will be incapable of holding water the excavations should slope in such a way that the water will drain away Better still avoid them altogether

When new roads or railways are built numerous culverts must be provided in order to ease the flow of water which is often obstructed by the new earthworks Suitable drainage preferably underground is essential. Mill dams on rivers also interefere with natural drainage and should be carefully checked

The clearing of forest in Africa favours the spread of *A gambiæ* clearing of jungle in the East favours such mosquitoes as *A maculatus* and *A minimus* so wherever possible the natural cover of the land should be preserved.

The installation of a piped water supply will do away with the need of storing water in pots tanks wells etc.

Larvæ are got rid of in many different ways but the tw...

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The installation of a piped water supply will do away with the need of storing water in pots, tanks, wells, etc.

Larvæ are got rid of in many different ways, but the two main methods are by drainage and by the application of substances which kill the larvæ. Find out first which species of the local mosquitoes it is necessary to destroy. Which for instance are the malaria carriers?

as Gambusia, may be introduced into the well and control obtained in this way Fish are also employed in reservoirs, tanks etc Breeding in rocky streams may

killed Then, near the coast the sea water may be introduced into a lagoon, and the increase of salinity will kill the larvæ Swamps can often be dried up by planting trees in them the excess water is first intercepted by temporary ditches and mosquito breeding in these has to be carefully controlled for the first few years after the plantation has been made It is important to find out first if the swamp is really breeding dangerous species of mosquitoes because in many countries they do not do so and only comparatively harmless species are found in the swamps

4 **Aedes Control**—This is a special subject which is described here separately because it is a sure way of eradicating the menace of yellow fever For success it is essential to have an organisation capable of carrying out repeated house inspections to search for and destroy containers holding Aëdes larvæ Every house in the area is visited once a week and the details are written up on a special form and on the house card itself The inspectors are checked in turn by senior inspectors by chief inspectors and by the person in charge and it is only by this repeated cross checking that good results can be obtained

Most Aëdes control organisations also include (a) an

crete or with a mixture of bitumen and sand A simpler method of *Aëdes control may be the application of* residual D.D T or gammexane to all the houses in the town

Simulium

Identification.—The species of *Simulium* are small black two winged flies of rather stout build and with a humped back They are well known wherever they occur

Life History and Habits.—The stages are the same as in mosquitoes The eggs are laid in masses on rocks under water The larvæ have suckers on their hinder ends and attach themselves by these to a rock but are also capable of crawling Their food is much the same as that of mosquito-larvæ In Africa the most important species are *Simulium damnosum* and *S neavei* They appear to like rapidly flowing rivers and streams with many cascades and water falls *S neavei* likes streams deeply shaded by forest In Central America the important species is *S ochraceum* breeding in very small streams and rivulets The pupæ are contained in cocoons which are fastened to a rock and do not swim about The fly hatches under water, rises to the surface and flies away after its wings are hardened

The females have a particularly irritating bite but the males do not bite The females bite by day especially in shady places near rivers

Diseases Transmitted—The only disease known to be transmitted by *Simulium* is Onchocerciasis The cause of this disease is a small worm and it is transmitted in the same way as the worm which causes Filariasis

Control.—The *Simulium* vectors of onchocerciasis can be completely and permanently eradicated by dripping an emulsion of D D T into the infested rivers Two parts of D D T per million of water are sufficient under suitable conditions to kill all larvæ and pupæ for at least a distance of 15 miles down stream The D D T is applied every fortnight for 3 or 4 months and as far as possible all the rivers in the area should be treated simultaneously The dosage has to be worked out in relation to the flow of the water (in cusecs) and where this is very great as in the Nile or Congo the method is probably inapplicable The highest point up stream to apply the D D T is determined by finding the point above which the vector species is absent

SAND FLIES

Identification—The sand fly or *Phlebotomus* (Fig is a very small insect—much smaller than a mosquito—with a hairy moth like appearance and two oval lanceolate wings The eyes are conspicuous and black

Fig ■ —A Sandfly (*Phlebotomus*)
(Wenyon s Protozoology)

Life History and Habits—The long eggs are laid in cracks and crevices in dark moist ground in rubbish in the shade of old buildings in caves etc The eggs hatch in ten days into larvæ which feed on the organic matter around They go through a pupal stage and after about a month the adults emerge *The female of some species* attack man in the evening as soon as the sun begins to set. They are so small that they readily pass the usual

FLIES

Identification.—All flies have two wings The flies dealt with in this section are stout bodied, and this ■ once distinguishes them from the slender bodied mosquitoes and sand flies They are much larger than *Simulium* and do not have humped backs

Life History and Habits.—With some exceptions which will be mentioned below, flies go through the same stages as mosquitoes—egg larva, pupa and adult The eggs are laid on human fæces, cattle droppings bad meat or dead animals and various other refuse, the eggs *hatch very quickly (usually in a few hours)* The larvæ are white grubs, tapering from behind forwards and with no legs or distinct head they are known as maggots They feed for a few days and then burrow into the ground where they become pupæ After a short time which varies according to climate, the adults hatch from the pupæ, crawl up through the earth to the surface and fly away

The adults of some flies suck blood through ■ proboscis rather like that of a mosquito, but stouter and shorter Most species however do not bite but feed on a great variety of substance, including human food and filth

House Flies

Identification—Rather small flies, usually dark grey or black with pale grey or dull yellow markings All belong to the genus *Musca*

Life History and Habits.—The life history ■ as described above The principal breeding places are droppings of man and cattle, domestic refuse, coffee pulp, decaying cotton seed and many other kinds of vegetable refuse Different species prefer different types of breeding places

The adults feed both on filth and human food

Diseases Transmitted.—There are three ways in which diseases are commonly transmitted by house flies

1 When a fly is examined under a lens it will be seen that it has many hairs, especially on its legs When it settles on filth, bits of the filth (which may contain disease germs) stick to the hairs and are easily transferred to clean food

2 If a fly is watched while feeding, it will be seen to regurgitate a drop of liquid (that is to say, return liquid from its inside as if it were vomiting) and to suck the drop up again This is because a fly is unable to feed on solid food and the regurgitated liquid, which is mostly water, dissolves such substances as sugar and enables the fly to suck them up The liquid often contains disease germs, and some are left behind on the food.

3 Many disease germs can pass through the fly's intestine unhurt, and be passed out with its fæces still dangerous to man These fæces are often deposited on human food and thus infect the latter

The principal diseases carried by house flies are as follows

1 **Dysentery.**—The organisms of both amœbic and bacillary dysentery are picked up by flies from the fæces of infected persons and transferred to clean food either on the fly's hairs or by the regurgitation method

2 **Typhoid** can be contracted in various ways, but especially either by personal contact with an infected person or by the consumption of water, milk or food infected with the germs This infection of food is often caused by flies either by carrying the bacteria on their hairs or by the regurgitation method Some people have large numbers of typhoid germs in their gut without showing any sign of the disease, such people are known as "carriers," and their fæces are full of the germs which thus become readily available to flies

3 **Tuberculosis.**—Flies obtain the germs of this disease from the fæces or sputum of an infected person The germs pass unharmed through the fly's intestine and may be deposited on food with the fly's fæces

4 **Other Diseases**—The house fly may cause the spread of yaws by carrying the germs from a yaws ulcer to an ordinary sore which *subsequently develops into* yaws Flies are thought to be concerned in the trans mission of poliomyelitis (infantile paralysis) by convey ing the virus from infected fæces to food or drink. Amongst other diseases cholera must be mentioned as an occasional fly borne disease though it is more often transmitted by infected water

Control—The chief points of importance in reducing flies and the diseases carried by them are

1 To abolish places in which flies breed

2 To make sure that no human fæces or other material from which they can obtain infection are available to them

3 To see that even if they become infected they have *no chance of infecting human food.*

The most important way in which these results can be obtained are

1 Building proper fly proof latrines and seeing that people use latrines instead of going outside in the bush

2 Burning or burying all rubbish to destroy breeding places

3 *Getting rid of all cattle droppings either* by spreading them out on ground which is to be cultivated and digging them in later, or by storing them in a pit well covered with earth until they can be used for manure The use of them in this way is also very valu able for non medical reasons as it greatly increases the crops which will be obtained

4 *Covering all foodstuffs (especially milk)* so that flies cannot foul the food

5 D D T or gammexane" can be used to great advan tage in reducing the number of houseflies The insecti cide can either be sprayed on to windows doors and other surfaces upon which flies like to rest indoors or on to the actual breeding places of the flies Here it acts not on the immature stages but upon the emerging adult

Blowflies and Flesh Flies.

Identification.—The principal flies which are included in this group are (1) blowflies or bluebottles (*Chrysomia* and *Lucilia*) (*see Fig.* 95) (2) flesh flies *Sarcophaga*) (3) the fly of the Congo floor maggot (*Auchmeromyia* and

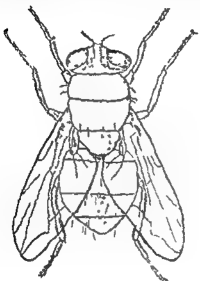

FIG. 95.—A BLOWFLY

Life History and Habits.—The life history is the same as that of the house fly (p 310), except that the female

of closed scissors while in all other biting flies the wings are held in the same position as the blades of a partly opened pair of scissors (Fig 96)

Life History and Habits—It has been mentioned that in *Sarcophaga* the eggs hatch within the body of the female so that she lays tiny larvæ instead of eggs In *Glossina* the process is carried a step further and the

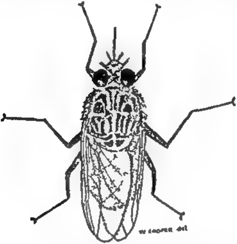

Fig 96—A Tsetse Fly (*Glossina*)

larva is kept within the body of the female until it is ready to pupate (see Fig 97) The female then deposits the larva on the ground in some suitable place and it immediately burrows into the ground and pupates without feeding Because the larva is protected within the body of the female fly until it is ready to pupate it escapes many of the dangers which other larvæ have to face and in consequence it is unnecessary for very large numbers of young to be produced so that some

may survive, and tsetse breed slowly and only produce small numbers of larvæ This is very important because it means that methods of control which kill comparatively small numbers of tsetse may reduce their numbers considerably, whereas such methods would be of little use against other insects which breed rapidly and produce large numbers of young The larva remains within the body of the female for about a fortnight, and only one is produced at a time

FIG 97 —A PUPA OF A TSETSE FLY

There are large numbers of species of tsetse, and the breeding places differ more or less for each species All species need some shade for the pupæ, and earth which is not too dry or too damp and which is soft enough for the larvæ to be able to burrow into it easily The pupæ also need shelter from rain Favourite breeding places are under fallen trees and at the roots of trees or bushes

The habits of the adults also vary according to the species, but all feed by sucking blood, unlike mosquitoes, both male and female tsetse bite and suck blood. Some prefer the blood of man and others prefer that of cattle or wild animals, but most species which feed on cattle or wild animals will also bite man An important species (*Glossina palpalis*) only occurs near lakes or rivers, usually in forests where there are open spaces (along a stream, for instance) and undergrowth Other species prefer bush country to forest, and may be found far away from water Most tsetse bite by day, but there are some which bite at dusk, or even at night, and are difficult to find during the day

Diseases Transmitted.—The very dangerous disease known as sleeping sickness is carried by certain species of *Glossina* There are two forms of sleeping sickness, Rhodesian carried by *Glossina Morsitans* and *Swynnertoni* and Gambian carried by *Glossina palpalis* and *tachinoides* Other species carry a very fatal disease of cattle, which is caused by an organism very closely related to

useful in small areas or in large areas which have been broken up into sections by means of clearings They include traps for pupæ and for adults and hand catching of adults

Traps for pupæ are made by setting up shelters (either fallen trees or small thatch roofs) in which the female tsetse can deposit her pupæ If these shelters are properly made the female fly often prefers them

may be caught but none has proved more than partially successful

A method which has proved useful for small streams *but less so for larger rivers and lake shores* is hand catching the fly in blocks of bush half a mile to a mile in length, separated from each other by clearings a quarter of a mile or so in width The flies are caught by hand nets and within a year may be completely elimin *nated by this method*

4 **Inspection of People**—People living or working in areas where the tsetse flies are infected are inspected at regular intervals by doctors to see whether they are infected with sleeping sickness This is done partly because it is much easier to cure the disease if it is discovered early but much more in order to be able to prevent infected people going into places where they will be bitten by tsetse and thus pass the disease on to others Inspection of people travelling from an area where the tsetse are infected is particularly necessary In

G morsitans because they breed over a much wider territory By altering the character of the bush that is by cutting out the vegetation particularly favoured by the

fly, it is possible to reduce the numbers of this species considerably This is called "discriminative clearing."

In the future, it is likely that DDT or gammexane" may supersede all the other methods. Spraying large areas of bush from the air has already abolished the fly from certain parts of Africa and when a cheaper way of doing this is discovered eradication on a really wide scale may result

Insecticidal smoke canisters provide another method of attacking the tsetse fly They contain DDT or "gammexane and the smoke is allowed to drift into the bush th

FLEAS

Identification—Fleas are small wingless insects which are strongly flattened from side to side (not from above downwards as in the case of bedbugs) (see Fig 98) This shape distinguishes them from all other insects In addition their well known habit of jumping is very rare among insects though it is shared by a few other groups

Identification of the genera and species of fleas is too difficult to be done by anyone but an entomologist.

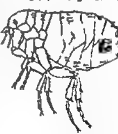

Fig 98—A Flea

Life History and Habits.—The female rat flea lays her eggs either in the nest of a rat or in the dust where the rat is in the habit of feeding The eggs hatch into very small worm like larvæ which feed on small food particles in the dust blood

contact with the fur of the rat and the flea density is very quickly reduced A 5 per cent oil spray is also effective

Rat and Flea Surveys.

Rat and flea surveys are done in order that we can find out what are the species responsible for plague in the place concerned, whether the field rats are taking any part in the spread of plague, and whether plague is coming from any particular kind of building or any particular part of the town This information all helps in planning control of plague

To carry out a survey of this kind, the rats must be caught alive, because fleas start to leave a rat as soon as it is dead and begins to get cold For this reason we cannot use "nipper" traps, although these catch more rats, but must use cage traps

The traps are baited with food attractive to rats, of which the most convenient are raw sweet potato or cassava and roasted or raw groundnuts (these have to be wrapped up in dry leaves or tied up to make a little parcel) It is a good thing to change the bait now and then, especially if not many rats are being caught The traps are mostly set in buildings where there are traces of rats but some should also be set in the open in rat runs among the grass The traps are visited daily and any which contain rats are brought back to the office

The traps are then placed one by one in a box with a tight fitting lid, and the rat and fleas are killed either with chloroform or with cyanogas A piece of white paper is placed to cover the bottom of the box, so that any fleas which fall off the rat can be easily collected off the paper The trap is then taken out of the box and the rat [illegible]

the rat the place and the date The rat is skinned and labelled with the same number, place and date

concerned Some fleas occur almost entirely on field rats and others mostly on house rats, so that the species of the fleas indicates whether the house rats and field rats are coming into contact, and the probability or not of the latter being concerned in the plague problem Many of the fleas found on field rats are very unwilling to bite man, and are therefore unlikely to transmit plague to a human case

The sex of the rats, whether they are adult or young and the number of young in pregnant female rats should also be recorded, as these facts give information about the breeding season of the rats

TICKS

Identification.—Ticks are not insects, and can be dis tinguished from all insects by the fact that the adults have four pairs of legs instead of only three pairs No ticks have wings There are very many species but most of them feed ...

Africa), *talaje* and *turicata* (in America)

The hard ticks (distinguished by the projecting head parts and proboscis) also transmit human diseases, impor tant species being *Dermacentor andersoni* and *Rhipicephalus sanguineus.*

Life History and Habits.—Both the young and adults of ticks feed only by sucking blood The female lays batches of a hundred or more eggs a number of times in her life The eggs hatch in about three weeks and pro duce nymphs, which are very like the adults except that they are much smaller and have only three pairs of legs

MITES

Identification.—Mites resemble ticks in having four *pairs of legs but they are very tiny creatures, less than* a millimetre in length There are two kinds of medical importance, *Sarcoptes* and *Trombicula*

Life History and Habits.—The female *Sarcoptes* burrows into the skin of a person to give rise to the condition known as scabies The chief regions affected are the fingers and wrists and the buttocks The female lays eggs in a tunnel in the skin, the eggs hatch and the larvæ and nymphs live on the surface of the skin or in small but not permanent burrows The mites give rise to an intolerable itching, worse at night

occurrence All cases should receive proper treatment and clothes should be sterilised by boiling

Trombicula mites are difficult to control and at present the best weapon against them is to avoid getting bitten Frequent baths, constant watch for mites on the skin avoidance of infected bush, give some protection Clothing *impregnated with dimethyl phthalate (see* *p 000**) is* the best preventative measure and remains effective for a week

THE PREPARATION AND USE OF INSECTICIDES

Four insecticides or repellents will be described, pyrethrum, D D T, "gammexane" and dimethyl phthalate

Pyrethrum powder.—This is prepared by drying the flower heads of the pyrethrum plant The active principles are pyrethrins which act as contact poisons on insects, probably paralysing the nervous system A good quality powder must be used, this should have been kept in the dark in a dry, cool place and in a sealed container

If these conditions are not observed there will be a great loss in potency of the pyrethrum One pound of powder is soaked in 1 gallon of kerosene for 48 hours with occasional stirring The oil is then strained and the residue thrown away It is best to keep the solution in the dark in stoppered bottles The solution is used as a fine spray or mist It has to be well atomised because it acts by direct hit on the insect The ordinary hand flit spray can be used but if large buildings are to be treated it is better to use a pump with a separate glass atomising container (aerograph pressure spray) A convenient but more expensive method is the freon bomb which releases a very finely atomised spray into the atmosphere and so many seconds of spraying with this appliance will disinfect a known sized room An adequate dosage of the kerosene solution is 15 30 ccs (half to one ounce per 1,000 cubic feet.

The important things to remember about pyrethrum spraying are —

1 Use a good quality spray The solution should contain 0 15 per cent pyrethrins
2 Use a well-made strong flit gun
3 Remember that the pyrethrum acts directly on the insect There is no residual effect, so if mosquitoes are numerous it is necessary to spray several times in the course of the day

Pyrethrum is usually harmless to man and domestic animals though a few people are sensitive to it and develop a rash.

D D T—This is a white powder practically insoluble in water but soluble in various oils It is not a pure substance and the percentage of the active principle varies in different samples from 55 per cent to nearly 90 per cent. In working out correct dosages it is essential to find out the strength of the sample There are four common ways of using D D T as a solution in oil as an emulsion as a suspension and as a powder

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Different mites carry various forms of typhus Scrub typhus is carried by the harvest mite, *Trombicula* The [illegible]

rodents act as reservoirs of the disease

Method of Control—Scabies is a disease of dirt and the ordinary processes of cleanliness will prevent its occurrence All cases should receive proper treatment an[illegible]

[illegible]

Fr[illegible]

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D D T. In oil.—D D T dissolves most easily in warm kerosene, and power kerosene is better than the lighting oil. Cut a 44-gallon drum in half and use the lower portion as a water bath with about 12 gallons of water

usual type of sprayer or from aircraft The emulsion mixes with water of the breeding place and does not remain on the surface Therefore the larvæ of those mosquitoes which spend much of their time under water —such as certain Culicines—are very easily killed by this method

D D T emulsion can also be used as a residual insecticide in houses and is as effective as the kerosene solution.

D.D T Suspensions—These are also called "wettable powders" and are bought ready made First add a little water to the powder to form a cream then add the remaining water in the required proportion with vigorous stirring A semi permanent suspension of D D T is the result It should be agitated during use owing to the tendancy for the powder to settle This preparation again is useful because it is easy to carry and the cost of transport of material is reduced The dilution is made on the spot In certain types of houses particularly the mud huts this form of D D T gives the best results against adult mosquitoes

D.D T powder—Powders are widely used for domestic purposes the de lousing of a population is also carried out with this form of D D T The D D T is mixed with an inert base such as China clay talc or kaolin The mixing must be done very thoroughly and this requires a ball mill. A very fine powder should be the result and the powder will then be found to cling to the clothing

is required but it is often advisable in domestic use to repeat the application once or twice at fortnightly intervals It can be employed against flies cockroaches ants moths bees and many agricultural pests

"Gammexane"—This is a commercial preparation consisting of the active form of benzene hexachloride or 666. The usual preparations are powders containing about 12 per cent of active gammexane' Kerosene dissolves about 3 per cent of the crude form 0 4 per cent of gammexane" It can be applied in the same formu

lations as D D T that is, in kerosene solution, emulsion suspension or powder It is a very powerful insecticide but most forms have a rather unpleasant smell For most purposes it works as well as D D T It is probably less effective in *Simulium* control, but it is much more effective against ticks For the destruction of adult

foot The suspension is prepared by adding one pound of this powder to one gallon of water Equivalent dosages are recommended for an oil solution or emulsion (These dosages refer to the crude 666 and not to the "gammexane" active principle) As a larvicide about half a pound of 666 per acre either as a dust solution or emulsion, is effective against mosquito larvæ

Dimethyl phthalate—This is probably the best insect repellent yet discovered It is effective against mosquitoes, sandflies tsetse flies midges *Simulium* mites and probably other insects It will not repel ticks nor stinging insects like wasps It is a colourless slightly oily liquid with a faint pleasant smell. It is dabbed on to the skin of exposed parts of the body It must not get into the eyes or wounds and it will destroy certain substances like plastic e g, frames of spectacles fountain pens Under ordinary conditions in the tropics the repellent action lasts for about three hours though some effect persists for many hours afterwards The effect lasts a little longer if the substance is made up into a cream (say 25 per cent magnesium stearate and 75 per cent dimethyl phthalate)

One of the most valuable uses for dimethyl phthalate (or even better for this purpose dibutyl phthalate) is to repel and kill mites—particularly the Trombiculid mites which cause a form of scrub typhus For this purpose socks and trousers are thoroughly impregnated with the liquid such garments will then be lethal to mites even after 5 or 6 washes (in cold water)

The use of the new insecticides offers great possibilities in the control of tropical diseases It is now possible [redacted] destroy all the insect vectors of a disease in a district and in fact this has already been done in certain places But these insecticides have to be used intelligently and it is always best to get expert advice before starting on major control schemes Be certain also that the insecticides are of the proper quality and that the apparatus for applying them is in good order Like in all forms of insect control a method which will suit one place may easily fail in another so make certain of all the facts first. And lastly new techniques are continually being d scovered so the most modern method should be used wherever possible

CHAPTER IX

THE DESTRUCTION OF RATS.

Rat destruction and the protection of buildings against the entry of rats is a very important part of health work in all countries Rats always gather together in places which provide them with food drink and shelter

How to attack them—The first line of attack [redacted] to **remove their food supply** No refuse should be allowed to lie about and foodstuffs should be so stored that rats are unable to get at them In the house food should be kept in safes covered with gauze wire and placed in such a position that rats cannot gain access to them Waste food should be burned or should be put into covered iron bins until removal Note that all rubbish bins should be provided with lids and that the lids should be kept on the bins and not on the ground No grain crops sugar cane or sweet potatoes should be grown within a radius of 30 feet from the house Maize and other grain should be stored in rat proof grain cribs these can be made quite easily and cheaply and will more than repay their cost by the amount of grain which will be saved from destruction The second method of attack [redacted] to **take away any shelter or harbourage** wh ch may be used by rats The rat has many natural enemies—*e g* cats dogs hawks and so on—and it loves to find a place littered with rubbish heaps of stones piles of wood and

so on in which it may hide and obtain its food without danger No long grass heaps of stones bush timber or rubbish should be within 30 feet of any house If there is a cleared area round a house, rats fear to cross it because when doing so they may be easily seen by their enemies

The third method of attack is to destroy as many rats as possible by gassing poisoning and trapping

Gassing Rats [illegible]

a highly poisonous gas called hydrogen cyanide when exposed to the air It must be used with great care

Procedure in Gassing —The powder (cyanogas) is supplied in airtight tins which must be kept properly closed when not required for use A dust pump with a nozzle to which a flexible hose pipe is attached is used for distributing the cyanogas The room which is to be disinfested should be made as gastight as possible The hose pipe is inserted into the room through any convenient small aperture as for example under a door if there is sufficient space through a ventilator or a small pane of glass may be removed from the window for this purpose The persons engaged on the work and on the pump remain outside the room As soon as the powder is sprayed into the air of the room it gives up its poisonous gas which destroys any animal or insect life At the end of half an hour all doors and windows must be thrown open and no one should enter the room until at least another hour has passed Anyone who does so runs the risk of being poisoned If the house has a thatched roof the nozzle on the end of the hose pipe should be thrust into the thatch or cyanogas pumped in This should be done in many places to ensure that the whole of the thatch has been filled with gas The pipe should also be inserted into any rat holes that are found and the gas should be forced down them For the gassing of rooms about 5 pounds of cyanogas powder are used for every 1,000 cubic feet of air space to be treated

Precautions.—Remember that this gas is very dangerous and will destroy human life as easily as it does that of vermin, if proper care is not taken Everyone concerned must be warned of the poisonous nature of the gas and the premises should never be left unguarded until all the rooms have been opened up and are completely free from gas When fastening doors and windows it is a good plan to fix them in such a manner that they may be opened without entering the room This may often be done by means of small wooden wedges driven into the joints between them and their frames from the outside

Sulphur dioxide will also destroy rats and insect pests It is used for disinfesting ships and railway carriages being forced into the holds and so on by means of a powerful machine called the Clayton apparatus

Poisoning Rats—Poisons in common use for the destruction of rats are phosphorus arsenic squills and barium carbonate

Care must be taken when laying poison baits that [illegible]

or buried

Barium carbonate is not very dangerous to children or to animals other than rats and is therefore a good poison to use for this purpose The bait should be made as follows

1 part barium carbonate
3 parts mealie meal, rice flour or ground nuts

The mixture should be made into a stiff paste with water ghee or molasses and then shaped into pills about the size of a one-cent piece in diameter If water is used in making the pills they will fall to a powder again when dry Those made with ghee or molasses last longer and are more easily taken from place to place without damage

Trapping Rats.—Traps of the break back variety are probably the most efficient, but during plague epidemics

it is safer to use wire cage traps which catch the rats alive and therefore their fleas along with them Fleas leave the body of a dead rat as soon as it is cold and

been used otherwise the rats become suspicious and will not enter them Traps may be baited with bread fish

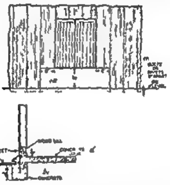

FIG. 99.—DETAILS OF A RAT PROOF STORE

meat etc. They should be examined every day After having been in position for a week they should be *removed and a week should be allowed to pass before* they are replaced.

Birdlime—This may be smeared on boards having the bait in the centre It is a very efficient though cruel method of catching rats and as it catches them alive it prevents the escape of fleas

Making Buildings Rat proof—Ginneries and other buildings used for the storage of materials such as seed cotton flour maize and so on which attract rats should be made rat proof This can be done as follows

(a) All door sills are to be 3 feet above the ground outside *the building, smooth plastered plinths* are to be provided below the sills, extending 2 feet on each side of the doorway [see Fig 99 (*a*)]

(*b*) The lower edges of corrugated iron sheet walls are to be set 6 inches in the ground, with 4 inches of fine cement concrete on each side of the sheet and 4 inches below the lower edge [see Fig 99 (*b*)]

(*c*) The lower 3 feet of the vertical laps of the wall sheets are to be held together with small rivets or bolts 9 inches apart, to prevent the laps gaping [see Fig 99 (*c*)]

(*d*) The floors are to be of cement concrete at least *3 inches thick or of burnt bricks 4½ inches* thick, or of ironstone set in cement mortar and 6 inches thick [see Fig 99 (*d*)]

(*e*) When the store is in use, the ground must be kept free of long grass, etc, for a distance of 20 feet on all sides

APPENDIX I

MENSURATION NOTES

Definitions.

A parallelogram is a four sided figure whose opposite sides are parallel

A rectangle is a parallelogram whose angles are right angles

A square is a rectangle all of whose sides are equal.

A rhomboid is a parallelogram whose opposite sides only are equal and whose angles are not right angles

A rhombus is a parallelogram having equal sides and whose angles are not right angles

A trapezoid is a four-sided figure that has only two of its sides parallel

Principles for calculating Areas

Areas.—*By "area" we mean the surface measurement*—i e the amount of surface included within the lines of a figure Area is expressed by stating the number of unit squares required to cover this surface

The unit square has a side equal to the length of the unit desired to be used Thus if we wish to obtain our measurement in square inches the unit square has a side of 1 inch (see Fig 100)

Rules for calculating Areas.

(1) Four-sided Figures

(a) *If the opposite sides are parallel* these are called parallelograms (i e rectangle square rhomboid and rhombus) The method of calculating the area is the same for all.

Rule.—The area of any parallelogram is found by multiplying the length of base by the altitude, or width

$$\text{Area} = b \times a$$

The *altitude* is the perpendicular distance between the parallel sides

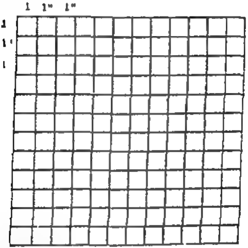

FIG 100

Diagram represents 1 square foot. To cover a surface of this area 144 squares equal to the unit square with the side of 1 inch are needed

(2) Triangles, or Three-sided Figures.

These are named according to their sides and angles

(a) An isosceles triangle has two of its sides equal.

(b) An equilateral triangle has three equal sides

(c) A scalene triangle has all its sides of unequal length

(d) A right angle triangle is any triangle having one right angle

The *base* of a triangle is the side on which it is supposed to stand (N B —Any side may be taken)

The *altitude* of any triangle is the perpendicular distance from the base to the apex.

Rules for calculating the area of any triangle

(a) When the length of the base and the altitude are known

$$\text{Area} = \tfrac{1}{2}\ \text{base} \times \text{altitude}$$

(b) When the lengths of the three sides are known

$$\text{Area} = \sqrt{S\ (S-a)\ (S-b)\ (S-c)}$$

S = half the sum of the lengths of the sides

a b and c = respective lengths of each side of the triangle

Example —Find the area of a triangle whose sides are 3 4 and 5 inches Then

$$S = \frac{3+4+5}{2} = 6$$

$$S-a = 6-3 = 3$$

$$S-b = 6-4 = 2$$

$$S-c = 6-5 = 1$$

$\therefore$ area $= \sqrt{6 \times 2 \times 3 \times 1} = \sqrt{36} = 6$ square inches

Right-angle Triangles—The longest side is called the "hypotenuse"

Rule —The square on the hypotenuse is equal to the sum of the squares on the other two sides or

$$a^2 + b^2 = c^2$$

Therefore, the length of the hypotenuse may be found as follows

Let the hypotenuse be called C and the other two sides a and b respectively, then

$$C=\sqrt{a^2+b^2}$$

To find the length of the remaining side when the length of the hypotenuse and a or b are known

$$a=\sqrt{c^2-b^2} \text{ and } b=\sqrt{c^2-a^2}$$

EXAMPLE 1—Find the hypotenuse of a right angled triangle whose sides are 3 and 4 inches

$$C=\sqrt{a^2+b^2}=\sqrt{3^2+4^2}=\sqrt{9+16}=\sqrt{25}=5 \text{ inches.}$$

EXAMPLE 2—Find the length of the remaining side of a right angled triangle whose hypotenuse is 5 inches and side 4 inches

$$a=\sqrt{c^2-b^2}=\sqrt{5^2-4^2}=\sqrt{25-16}=\sqrt{9}=3 \text{ inches}$$

EXAMPLE 3—If the span of a roof is 24 feet and its rise is 12 feet what will be the length of the rafters?

N B—If the two sides of a right angled triangle are of equal length the length of the hypotenuse may be found by multiplying the length of a side by 1 4142

Here the rafter is the hypotenuse of a right angled triangle and a and b are equal

Therefore $a\times 1\ 4142=12\ \times 1\ 4142=16\ 9704$ feet

Explanation

$C=\sqrt{a^2+b^2}$, therefore, if a and b are equal, then

$C=\sqrt{2a^2}$ or $\sqrt{2b^2}$

$\sqrt{b^2}=b$ and $\sqrt{a^2}=a$ and $\sqrt{2}=1\ 4142$

Therefore $C=1\ 4142\times a$ or $1\ 4142\times b$

Note.—The diagonal of a square is the hypotenuse of a right angled triangle having two equal sides

Therefore the diagonal $=1\ 4142\times$ side of square, and side $=$ diagonal $\div 1\ 4142$

(3) Circles.

The circumference of a circle is the distance around it.

The diameter of a circle is a straight line through the centre terminated on each side by the circumference. It divides a circle into two halves called "semicircles."

The radius is a straight line drawn from the centre to the circumference and is equal to the length of half the diameter.

The length of the circumference of a circle is always 3·1416 times the length of its diameter.

Rule 1.—Circumference $=\pi d$

N.B.—The Greek letter π (pronounced *pi*) is always used to represent 3·1416, or more roughly 3 1/7 and d = diameter.

Rule 2.—The area of a circle is found by

$$\text{Area} = \pi R^2 \quad (R = \text{radius}).$$

EXAMPLE 1.—*What is the area of a circle whose diameter is 10 feet?*

$$\text{Radius} = \frac{10}{2} = 5 \text{ feet}$$

$$\text{Area} = 5 \times 5 \times 3{\cdot}1416 = 78{\cdot}54 \text{ square feet}$$

EXAMPLE 2.—What is the radius of a circle whose area is 78·54 square feet?

$$\text{Radius} = \sqrt{\frac{78{\cdot}54}{3{\cdot}1416}} = \sqrt{25} = 5 \text{ feet.}$$

(4) Regular Polygons.

A polygon is a figure having more than four sides.

A *regular polygon* is one whose sides are of equal length.

A *pentagon* is a polygon having five sides.

A hexagon is a polygon having six sides.

Rule.—The area of a regular polygon is found by multiplying the perimeter by one half of the perpendicular distance from the centre to a side

Thus area = length of side × number of sides × half perpendicular distance from centre to side

Principles for calculating Cubic Space or Volume

The Measurement of Solids

A solid has three dimensions length, breadth and thickness

The volume of a solid is the space included within its sides and is expressed by stating the number of unit cubes required to fill the space

The unit cube has length breadth and thickness equal to the unit desired to be used—e g , if we desire to express our measurement in cubic feet the unit cube will have sides 1 fo [illegible]
1 cubic fc [illegible]
feet broac [illegible]
In other [illegible]
cubic yard

A **cube** is a rectangular solid whose sides and ends are squares

A **rectangular** solid is one whose sides and ends are rectangles

Rule.—The volume of any rectangular solid is found by

Volume = length × breadth × height.

A **cylinder** *is a solid whose ends are parallel and whose* section is a circle

Rule 1—Volume of a cylinder = area of base × height.

Rule 2—The relative capacity of cylinders of equal height is as the square of their diameters.

A **cone** is a solid whose base is a circle and whose surface tapers to a point called the "vertex."

Rule—Volume of a cone = area of base × *one-third* altitude (the altitude is the **vertical height**)

vegetables, fruit, meat, poultry, provisions, etc) Milk and milk products Inspection of food Food in relation to communicable disease Inspection of animals before and after slaughter The recognition and inspection of carcasses, joints, and organs of animals used for human consumption The diseases of animals intended for food, the appropriate action in regard to diseased meat

Air, Ventilation and Lighting—The composition of air and the various causes of pollution The principles of ventilation and simple methods of lighting and ventilating rooms and buildings, including schools, factories, etc Measurements and calculations of areas, cubic space, etc

Building Construction and Sanitation.—The advantages and disadvantages of various sanitary appliances, the inspection of builders' and plumbers' work, the interpretation of drawings and of specifications Selection of sites (aspect, characteristics and composition of soil) Alignment (spacing from adjoining houses and streets) Area of site to be built upon

Drainage, Sewerage and Sewage Disposal—A knowledge of various systems of drainage and their adaptability to particular conditions, construction of drains, levelling and methods of drain testing Sewage treatment and disposal

Collection and Disposal of Excreta and Refuse—Scavenging and various systems for dealing with trade, house and other refuse

Disposal of Dead—Supervision of cemeteries, etc

Village and Rural Sanitation (including Sanitation of Fairs and Festivals)—Selection of sites for villages Lay out of building plots Roads Open spaces Sanitary plots Markets Schools Public buildings Construction of field incinerators, fly proof pit and bore hole latrines, modified septic tank latrines, etc Simple methods of protecting streams, springs, wells, tanks and reservoirs from pollution Purification of village water supplies Anti mosquito measures

Port Sanitation—Duties of a sanitary inspector in connection with shipping and aircraft

Prevention of Disease—Nature of infection sources and mode of spread Incubation periods and Quarantine periods of communicable diseases Preventative measures against communicable diseases special attention being given to diseases locally prevalent Practice in vaccination Intramuscular inoculation Disinfection including wells and tanks Isolation hospitals and immigration and quarantine camps Characteristic symptoms by which infectious diseases deaths from which have to be commonly recorded, can be recognised

Entomology—The life histories of the common mosquitoes the flea the louse the tick the tsetse fly the common domestic fly and a knowledge of how disease is conveyed to man by these insects A knowledge of measures of control of the above insects and other vermin including rats

Students should be able to identify the more important species of insects included in the above

Helminthology—A knowledge of the common helminths that infect man in the tropics and methods adopted for their control—i e flukes schistosoma taenia (tapeworms) ascaris (round worms) hookworms etc

Statistics.—An elementary knowledge of the meaning of the terms and of the methods of calculating birth rate death rate and rate of infant mortality

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